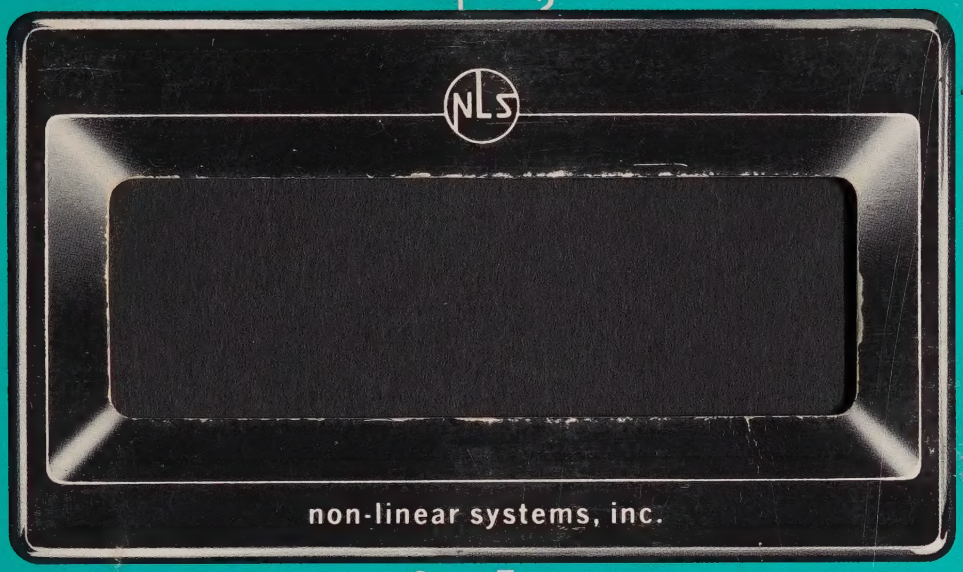

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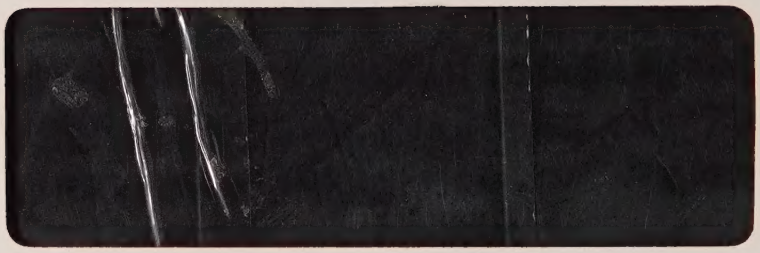

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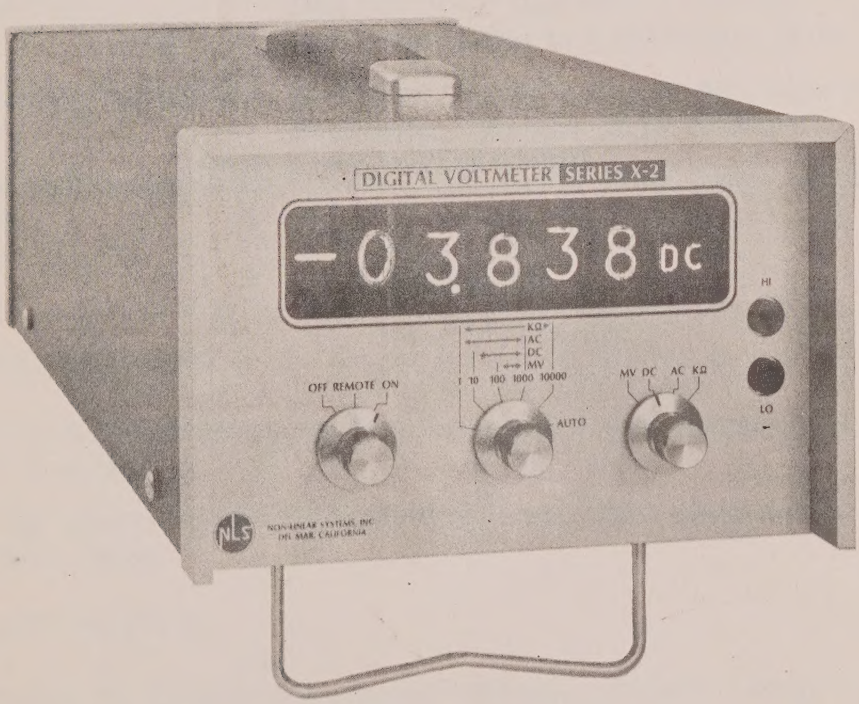
INSTRUCTION MANUAL

SERIES X-2 /W AC CONV.

DIGITAL VOLTMETER



Originator of the Digital Voltmeter

non-linear systems, inc.

DEL MAR, CALIFORNIA

Printed in the United States of America

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CAUTION

WHEN THE INSTRUMENT DESCRIBED IN THIS MANUAL IS INSTALLED IN A SERIES X-1-TYPE OUTER CHASSIS (FOR SYSTEM APPLICATION), REMOVE CABLE CONNECTIONS PRIOR TO REMOVING THE INSTRUMENT DRAWER ASSEMBLY FROM THE CHASSIS. FAILURE TO OBSERVE THIS PRECAUTION MAY CAUSE DAMAGE TO CABLE AND INSTRUMENT CONNECTORS.

Originator of the Digital Voltmeter
non-linear systems, inc.
DEL MAR, CALIFORNIA

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CHAPTER I

INTRODUCTION AND SPECIFICATIONS

The NLS Series X-2 Digital Voltmeter is a three-range, four-digit instrument with automatic polarity and with provisions for 20% over-ranging on the two lowest ranges. An automatic ranging feature is offered as an option. The instrument may be used as a bench model or, with the use of rack-mounting adapters, may be rack-mounted in a standard 19-inch mounting rack.

OPTIONAL FUNCTION ACCESSORIES

In addition to measuring DC voltages, the Series X-2 DVM is capable of measuring AC voltages, millivolts and ohms. These extra features may be obtained by utilizing optional plug-in modules. A K Ohms converter/pre-amplifier provides ohms and millivolt measurements and one of two types of AC converters (50 Hz to 10K Hz or 50K Hz to 100K Hz) provides AC voltage measurement.

GENERAL

The Series X-2 Digital Voltmeters are solid state integrating instruments that measure the absolute value of DC voltages or the integral of varying voltages. In these instruments the unknown input voltage is converted to a pulse train whose repitition rate is directly proportional to input voltage magnitude. The total number of pulses generated over a clocked 0.1 second interval is counted electronically and displayed as the voltage value.

OPERATING PRINCIPLE

An input of 10 volts to the instrument creates 10,000 pulses in 0.1 second; this is displayed as 10.000 volts. If the input voltage changes during the measuring interval, the pulse repetition rate changes proportionately, and the total number of pulses that occurs during the 0.1 second sample period is a measure of the number of volt-seconds at the input. Since these instruments mathematically integrate the input voltage, they are useful for obtaining the velocity from a voltage which is proportional to acceleration. In addition, these instruments are inherently able to reject sinusoidal ripple because the integrated value of an integral number of sine waves is zero. Therefore if an integral number of cycles of sine wave noise occurs during the 0.1-second sampling interval, its contribution to the overall reading is "integrated out".

DIGITAL OUTPUT

Beginning with serial number X-2.157, the instrument possesses a printout and remote triggering capability for operation with data printers, tape punches, typewriters and other recording devices. For printout, the Print Board Assembly, with pendant cable and connector, is offered as an option.

FLOATING INPUT

Because input signal leads may be disconnected from the Series X-2's outer chassis (by removing a shorting strap between J5 and J6 on the rear of the instrument), signal-to-chassis potentials up to 500 volts are permissible. Floating input adds to the DVM's versatility by permitting it to measure voltage sources which could not be accurately measured by a non-isolated meter.

COMMON MODE REJECTION

Rejection of common-mode signals, those

caused by AC or DC currents flowing between signal source ground and instrument chassis ground is a feature of the Series X-2 DVM. (To obtain CMR, the shorting strap described in the above paragraph must be removed.) Common-mode signal rejection is important in a wide range of applications - testing complex electrical and electronic systems, in automatic measuring systems, and measuring outputs from thermocouples, strain gages and other transducers where common-mode signals may be many times greater than the measured DC voltage.

PROCEDURE TO DETERMINE CMR

1. Turn the X-2 DVM on and allow 30 minutes for warm-up.

2. Remove shorting strap between J5 and J6.

3. Connect DVM to signal source and common-mode source as shown in Figure 1-1. Signal source is preferably a series string of three or four 1.5V batteries (flashlight cells or 1.3V mercury cells). To obtain an accurate measurement of CMR, the source resistance of the signal source should be less than 10 ohms. The output of a variac, connected as shown in Figure 1-1, will adequately provide the required common-mode source.

4. Set variac to zero volts then advance variac in voltage until a one digit "bobble" is observed in the least significant decade then, back off variac until "bobble" just stops. Measure the variac output with an AC voltmeter and convert to peak-to-peak voltage.

5. To obtain rejection ratio, divide peak-to-peak common voltage by 1 MV.

$$\text{Common-mode rejection radio} = \frac{E_{p-p}}{10^{-3}}$$

$$DB = 20 \log \frac{E_{p-p}}{10^{-3}}$$

$$DB = 20 \log 1,000\ E_{p-p}$$

6. For example, if the common-mode voltage is 3.5V

$$E_{p-p} = 3.5 \times 2.828$$

$$E_{p-p} = 10V \text{ and}$$

$$DB = 20 \log 1,000 \times 10$$

$$DB = 20 \log 10^{4}$$

$$DB = 20 \times 4 = 80$$

Common-mode rejection = 80 DB

The NLS Sales Representative or Engineering Department will be pleased to assist you with specific application problems and, of course, will gladly welcome your comments and suggestions.

SPECIFICATIONS

CIRCUITRY:	All solid state.
ANALOG-TO-DIGITAL CONVERSION:	Bi-polar integrator.
FULL SCALE DC RANGES:	±9.999, ±99.99, ±999.9 with 20% over-range on the two lower ranges.

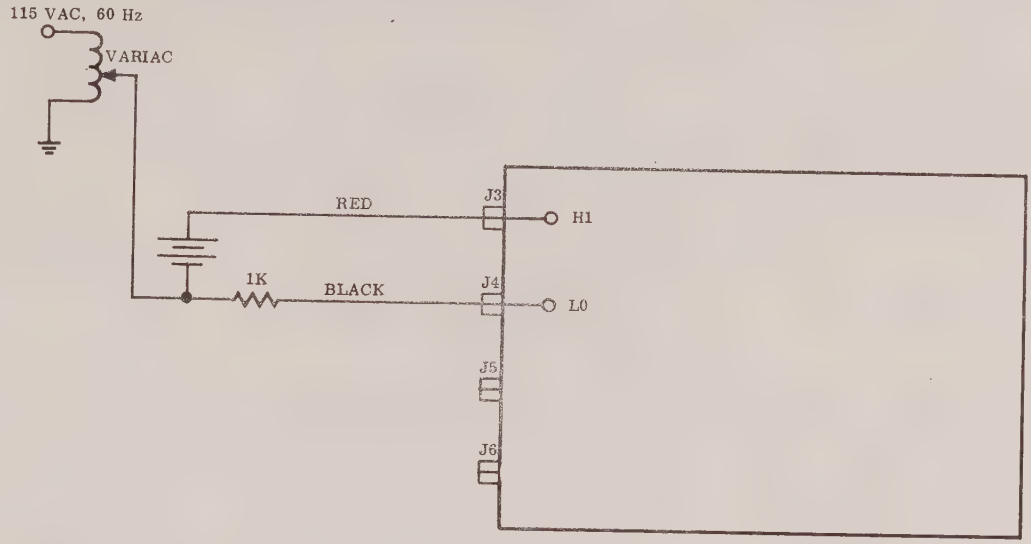


Figure 1-1. Connections to Determine CMR

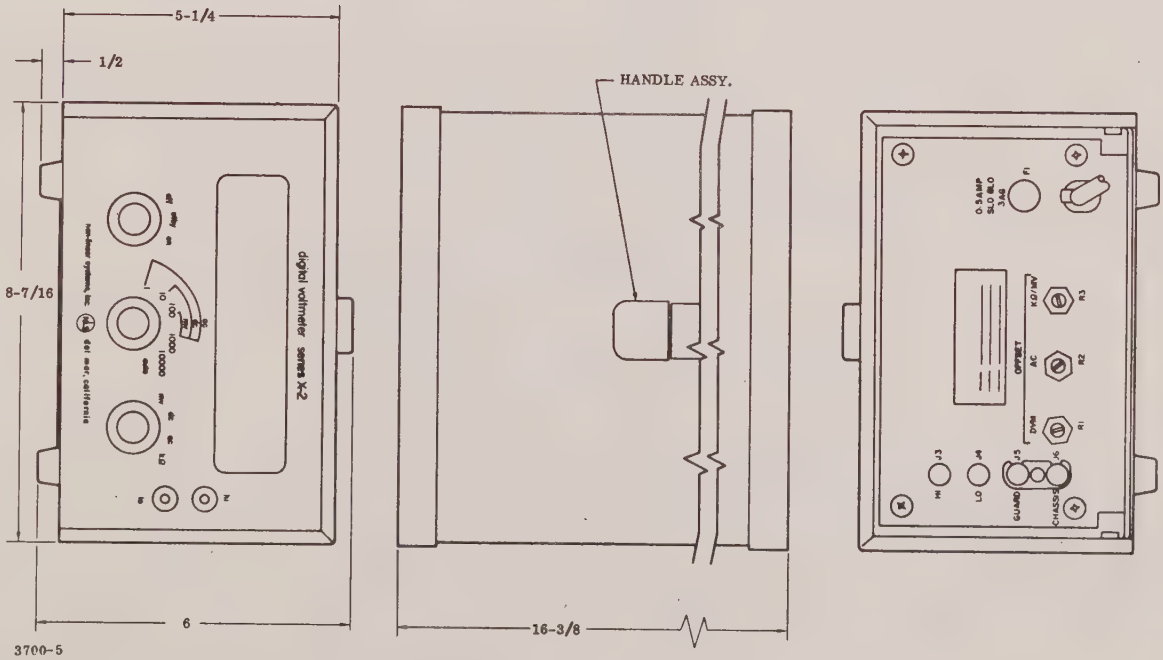


Figure 1-2. Series X-2 DVM Outline Drawing

ACCURACY AT ASA REFERENCE CONDITIONS:	±0. 01% of full scale ±0. 02% of reading.
RESOLUTION:	One digit.
RESPONSE TIMES:	Voltage-to-Frequency Converter Settling Time - 100 MS (with filter). Digitizing Time - 100 MS. Range Selection Time - 100 MS.
INPUT RESISTANCE:	10 megohms, constant all ranges, except when 20% over-range is exceeded.
COMMON MODE REJECTION:	100 DB @ DC; 80 DB @ 60 Hz +- 1KΩ unbalance
RANGE SELECTION:	Manual or Automatic/Manual (see options).
POLARITY SELECTION:	Automatic.
INPUT CONNECTIONS:	Front and rear. Input may be floated ±500 volts above chassis by removing shorting strap from rear input connectors.
AMBIENT TEMPERATURE:	Extreme - 12° C to 50° C.
POWER REQUIREMENTS:	105/125 VAC, 50/60 Hz.
MOUNTING POSITION:	Any.
WEIGHT:	12 pounds
SIZE:	5-1/4 inches (excluding feet and handle) x 8-7/16 inches x 16-3/8 inches.
OPTIONS AVAILABLE:	Automatic ranging.
ACCESSORIES AVAILABLE:	AC/DC Converters K Ohms/DC Converter and Pre-Amplifier Print Board Assembly - BCD 8-4-2-1 Logic "0" = 0 volt to +0. 5 volt, Logic "1" = +3 volts ±0. 1 volt Rack Mounting Adapters

AC/DC Converter, Types I and II for X-2

RANGES; including (20% over-range)	1. 1999/11. 999, 119. 99 & 500. 00 VAC
FREQUENCY RESPONSE	10K Hz 100K Hz Lower frequency converters are available on special order. The 10K Hz converter is usable to 30K Hz in the manual ranging mode

ACCURACY:	10K Hz	0.05% reading + 0.02% FS, 200 Hz to 3K Hz, 1000 VAC 0.1% reading + 0.05% FS, 50 Hz to 200 Hz and 3K Hz to 10K Hz, 1000 VAC 30 Hz accuracy is typically 0.3%
	100K Hz	Same as 10K Hz, plus: 0.3% reading + 0.1% FS, 10K Hz to 30K Hz, 500 VAC 0.5% reading + 0.1% FS, 30 K Hz to 100K Hz, 150 VAC
RESPONSE TIME		600 milliseconds to 0.1% of final value
INPUT IMPEDANCE		One megohm, shunted by 100 PF
RANGING		Automatic and manual

Ohms/DC Converter

ACCURACY	Four Digit	Maximum Current
±0.01% FS and ±0.02% reading (1KΩ, 10KΩ, 100KΩ and 1000KΩ ranges)	1.1999KΩ	10 MA
	11.999KΩ	1 MA
	119.99KΩ	100 μA
	1199.9KΩ	10 μA
±0.01% FS ±0.1%	11,999.KΩ	1 μA

STABILITY	0.05% full scale for at least 90 days on all ranges
RESPONSE TIME	100 milliseconds for step response. 200 milliseconds for step response with range change. 700 milliseconds on 10 megohm range
RANGING	Automatic and manual (Manual only 10,000K Range)
INPUT CONFIGURATION	Two wire with voltage protection

Automatic Ranging DC Preamplifier

RANGES	X10	±000.1 MV to ±1199.9 MV
	X100	±00.01 MV to ± 119.99 MV
ACCURACY	X10	±0.02% reading and ±0.01% Full Scale
	X100	±0.05% reading and ±0.05% Full Scale
GAIN STABILITY		0.01% for at least 30 days
ZERO STABILITY		Drift does not exceed ±50μV or ±5 digits, whichever is greater, for at least seven days at constant temperature.
INPUT IMPEDANCE		Greater than 100 megohms
RESPONSE TIME		500 MS for step response to 0.01%

CHAPTER II
INSTALLATION AND OPERATION

UNPACKING

The instrument is shipped in a heavy cardboard container. Cut the tape on the top of the container and open. If damage is seen, promptly notify the carrier.

MOUNTING

The instrument was primarily designed as a bench instrument, however, three types of mounting adapters for mounting in a standard 19-inch mounting rack are available at customer's option. One type may be obtained with an additional drawer for storage of tools, spare parts, etc; a second type will accommodate two Series X-2 DVM's; and the third type is a 19-inch front panel attached to the instrument.

CAUTION

Do not operate the instrument before ensuring that each plug-in board is firmly in place. Failure to take this precaution may cause damage to components on the board assemblies.

POWER SOURCE

The instrument is usually supplied for operation from 110-120-volt, 50-60 Hz, single phase power sources. However, the instrument will operate from 220-230-volt, 50-60 Hz, single phase sources if the two primaries of the power transformer are wired in series instead of parallel. The ventilating fan must be rated at the correct voltage (some modified instruments with S/N's between X-2.1 and X-2.157 have a ventilating fan; all instruments with S/N's X-2.157 and subsequent were shipped from the factory with a ventilating fan). The Serial No. tag at the rear of the instrument indicates the correct power source if other than 110-120 volts or 50-60 Hz.

FUSING

The instrument is protected by a 3AG one-half ampere fuse which is located in an extractor post on the rear panel. When a 220-230-volt power source is to be used (and the power transformer primary rewired as indicated above), it is recommended that a one-fourth ampere fuse be used to provide maximum protection.

POWER GROUNDING

The third pin of the power plug grounds the outer chassis of the instrument (Figure 2-1). Despite the presence of the third grounding pin, there is no real assurance that the instrument will be correctly connected since the power outlets in many installations are erroneously wired. Be certain that the power source is in agreement with the power and grounding requirements of the instrument.

CONNECTORS (S/N's X-2.1 thru X-2.156)

Two input connectors (J1 and J2, labeled HI and LO respectively) are located on the front panel of the instrument (Figure 2-2) and are wired in parallel with two connectors (J3 and J4) located on the rear of the instrument (Figure 2-3). Two additional connectors (J5 and J6) are located on the rear of the unit and under normal operating conditions are connected together with a shorting strap. To

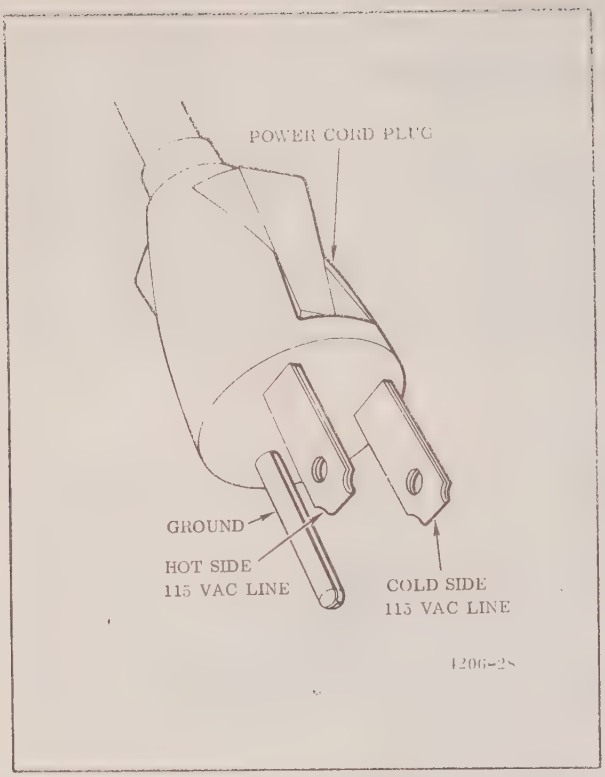


Figure 2-1. Power Plug Pin Coding

float the input above chassis ground (up to ±500 volts), the shorting strap must be removed.

CONNECTORS (S/N's X-2.157 & subsequent)

These instruments have the same input connectors as those described in the above paragraph and, in addition, have three remote triggering connectors (J17, J18 and J19) installed on the rear panel. If the printout option is elected, digital output connector J7 is also installed on the rear panel (see Print Board Assembly Schematic Diagram, 37-89, for connector pin information).

CABLE CONNECTIONS

The instrument is supplied with an input cable (P/N 2BC-AL-36) for insertion into J1 and J2 on the front panel or J3 and J4 on the rear panel. See Figure 2-4 for connection information. A mating connector is supplied for J7 when the printout capability option is elected.

CONTROLS

POWER SWITCH (S/N's X-2.1 thru X-2.156)

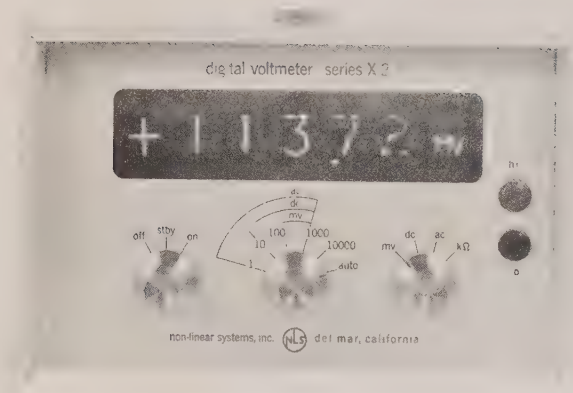
The power switch is located on the front panel of the instrument and has three positions (OFF, STBY. AND ON). The STBY. position is used to stop the instrument from taking further readings. The ON position commands the instrument to take readings at its maximum rate (allow 30 minutes for instrument warm-up).

POWER SWITCH (S/N's X-2.157 & subsq.)

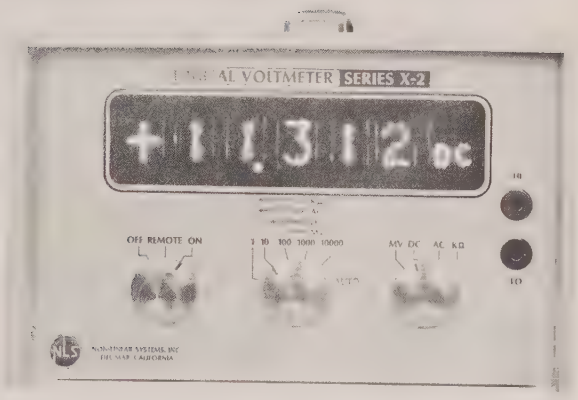
The STBY. position of the power switch on these instruments has been re-labeled REMOTE. In the REMOTE position, a print/record pulse is issued at the completion of each measurement; in the ON position this pulse is inhibited. In the absence of a remote triggering pulse, the REMOTE position serves as a standby control, i.e., the last reading taken remains stored in the readout.

To externally trigger the instrument by a recording device through connector J7, the shorting strap between connectors J17 and J18 must be kept in place. Each pulse applied through connector J7 will provide only a single reading. For each pulse applied, a delay of 180 MS will take place in the VDC, MVDC and K ohms functions and a delay of 900 MS will take place in the AC function.

With the shorting strap between connectors J17 and J18 removed, the instrument may also be externally triggered by a contact

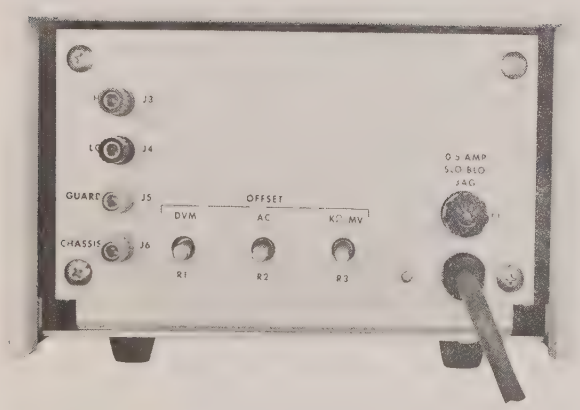


S/N's X-2.1 THRU X-2.156

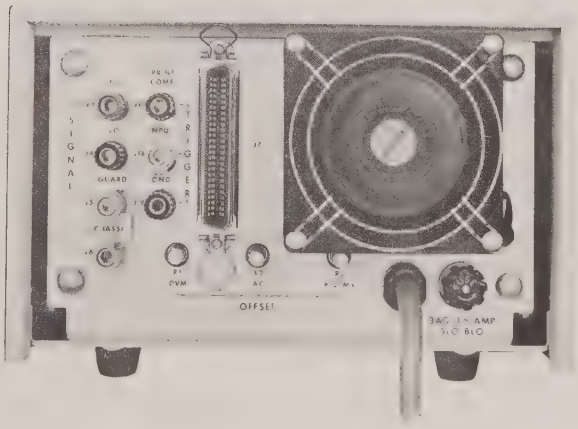


S/N's X-2.157 AND SUBSEQUENT

Figure 2-2. Front Views



S/N's X-2.1 THRU X-2.156



S/N's X-2.157 AND SUBSEQUENT

Figure 2-3. Rear Views

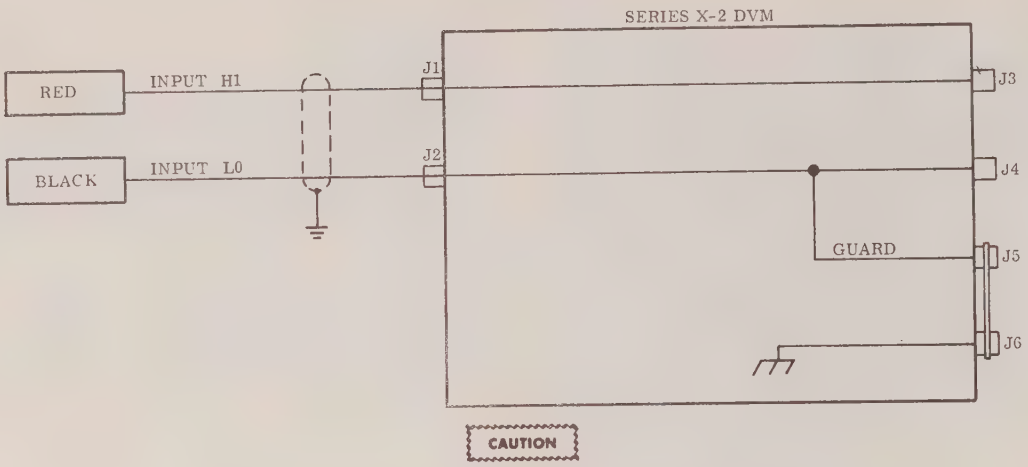


Figure 2-4. Input Connections

closure between connectors J18 and J19. For a single reading only, the duration of this closure must be less than 100 MS. Closures in excess of 100 MS (with the exception of range changes) will cause the instrument to continuously scan as long as the closure is applied.

To eliminate first-reading-error with either method of triggering, the input signal to be measured must be applied prior to the application of the triggering pulse.

RANGE SWITCH

The range switch is located on the front panel of the instrument and has six positions. (See table I.) When in the 1 position, the instrument is locked in the 1 volt range for the measurement of AC voltages or in the 1K range for the measurement of K ohms. When in the 10 position, the instrument is locked in the 10-volt range for the measurement of AC or DC voltages or in the 10K range for the measurement of K ohms. When in the 100 position, the instrument is locked in the 100-volt range for the measurement of AC and DC voltages, in the 100 MV range for the measurement of millivolts or in the 100K range for the measurement of K ohms. When in the 1000 position, the instrument is locked in the 1000-volt range for the measurement of AC and DC voltages, in the 1000 MV range for the measurement of millivolts or in the 1000KΩ range for the measurement of K ohms. When in the 10,000 position, the instrument is locked in the 10,000 KΩ range for the measurement of K ohms. If the instrument has the automatic ranging capability, the proper range is automatically selected when the switch is in the AUTO position. (The 10,000 KΩ range can only be selected

Table I. Measurement Capabilities

Function Switch Positions	Range Switch Positions: 1	10	100	1000	10,000	AUTO
MV	⊠	⊠	100 MV RANGE	1000 MV RANGE	⊠	100 MV or 1000 MV RANGES
DC	⊠	10 VDC RANGE	100 VDC RANGE	1000 VDC RANGE	⊠	10 VDC, 100 VDC, or 1000 VDC RANGES
AC	1 VAC RANGE	10 VAC RANGE	100 VAC RANGE	1000 VAC RANGE (500 VAC MAX.)	⊠	1 VAC, 10 VAC 100 VAC or 1000 VAC RANGES (500 VAC Max)
KΩ	1KΩ RANGE	10KΩ RANGE	100KΩ RANGE	1000KΩ RANGE	10,000KΩ RANGE	ALL EXCEPT 10,000KΩ RNG.

NOTE: The combined positions of the range and function switches as indicated by ⊠ above will produce erroneous readings.

manually.) With the switch in the AUTO position (if the instrument does not have the auto-ranging capability), the readout will not display decimals and the instrument will be in the lowest range of the particular function selected by the function switch.

FUNCTION SWITCH

The function switch is located on the front panel of the instrument and has four positions. (See Table I.) It is used to select the desired measurement function, either MV, DC, AC or KΩ.

OFFSET CONTROLS

Three screwdriver-adjust potentiometers are located on the rear of the unit. They are provided to zero the reading of the instrument in each of its measuring functions. The specific use of these controls is described in the calibration instructions.

DIGITAL READOUT

The instrument is normally supplied with six readout tubes: polarity display; over-range display; and four 0 thru 9 digital and decimal displays (left to right respectively). A function tube (displaying MV, DC, AC or KΩ) is offered as an optional accessory and when utilized is located on the extreme right of the readout. The polarity display (S/N's X-2.307 and subsequent) also indicates an overload condition, i.e., when the input exceeds the limits of a particular manually selected range, the left-most readout tube will display 1. With the range switch in the AUTO position, the overload display will only illuminate when the extreme limits of the instrument have been reached. Refer to specifications for limits of each measurement function.

CHAPTER III

CALIBRATION

In the calibration instructions provided in this chapter, it is assumed that the instrument is in good working order and only requires calibration. If any components are defective, it may be difficult, if not impossible, to calibrate the instrument.

SCOPE

The basic DC calibration procedure is divided into six distinct areas: reference adjustment; zero offset adjustment; 10-volt range calibration for a positive input; 10-volt range calibration for a negative input; 100-volt range calibration; and 1000-volt range calibration.

Since the Series X-2 instruments are capable of millivolts, AC and ohms measurements, calibration procedures for these functions are also included.

DC VOLTAGE CALIBRATION

EQUIPMENT REQUIRED

1. A voltmeter capable of measuring -20 VDC (±1 MVDC).
2. An extension board, NLS No. 1009-41.
3. A voltage standard between 9. 000 volts and 11. 998 volts.
4. A voltage standard between 90. 00 volts and 119. 98 volts.
5. A voltage standard between 900. 0 volts and 1000. 0 volts.

NOTE

It should be noted that the error in making a measurement with the Series X-2 DVM can be as much as the stated accuracy of the instrument plus the accuracy of the voltage standards used in its calibration.

INITIAL PREPARATION

1. Remove the cover of the instrument by removing the four screws (two on each side) attaching the cover to the chassis (Figure 3-1).
2. Plug the power cord into a 115 VAC, 50-60 Hz, single phase power source.
3. Place the power switch in the STBY. position and allow 30 minutes for instrument warm-up.

PROCEDURE

Reference Adjustment

I. Connect a voltmeter capable of measuring -20VDC(±IMVDC) between chasis ground and -20V test point(the red plastic test point) figure 3-3.
On newer models take the measurement between one of the test points in the upper left hand corner of the reference assembly (either the -20V or+20V terminal) and chasis ground.
Caution , Do not measure across the +20V and -20V terminals,doing so has a nulling effect.

2. Adjust RI(figure 3-3) until test meter reads -20V(±IMVDC).
On newer models adjust for a plus or minus 20V depending on the test point to which the high side of the meter is connected.

Zero Offset Adjustment

1. Place function switch in the DC position.
2. Place power switch in the ON position.
3. Place range switch in the 10 position.
4. Connect the red and black clips of the DVM input cable together.
5. Rotate the DVM OFFSET potentiometer R1, located on the rear of the instrument, to a position which causes the readout to display ±0. 000 DC.

10-Volt Range Calibration for a Positive Input Voltage

1. Connect the black lead of the DVM input cable to the negative terminal of the voltage standard described in paragraph 3 under Equipment Required. Connect the red lead to the positive terminal.
2. Apply approximately 9. 5 volts.
3. The numerical value displayed in the readout should be equal to the voltage of the voltage standard. If it is not, adjust potentiometer R30 (Figure 3-2) of the Attenuator Assembly, P/N 37-39, until the readout displays the correct value. Note that input impedance of DVM is 10 Megohms.

NOTE

Potentiometers R31 and R38 (Figure 3-2) have been adjusted and sealed at the factory and must not be adjusted in the field. They are temperature coefficient compensators for the ± prime calibration.

Figure 3-1. Cover Removal

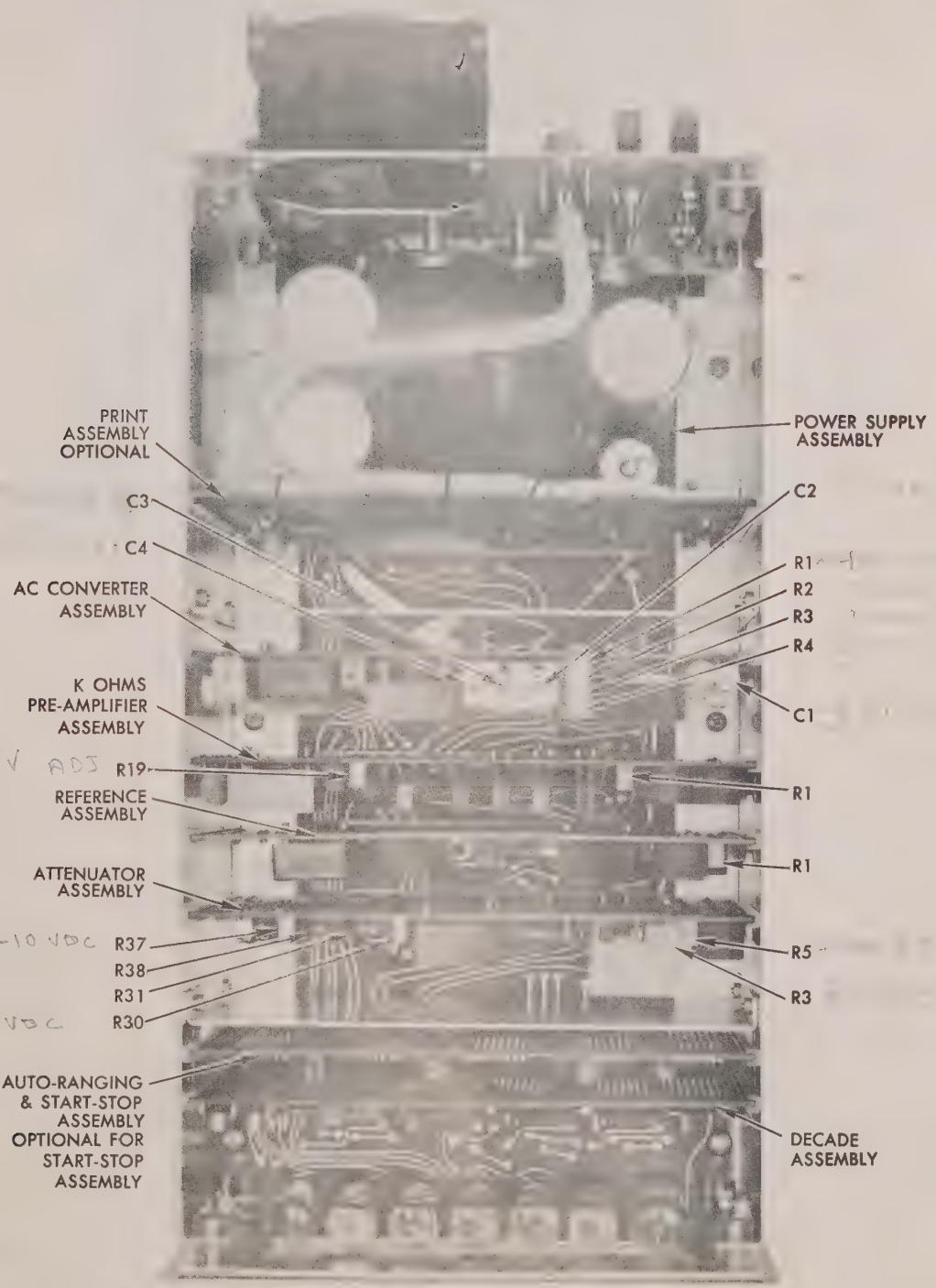


Figure 3-2. Location of Major Subassemblies and Adjustment Points

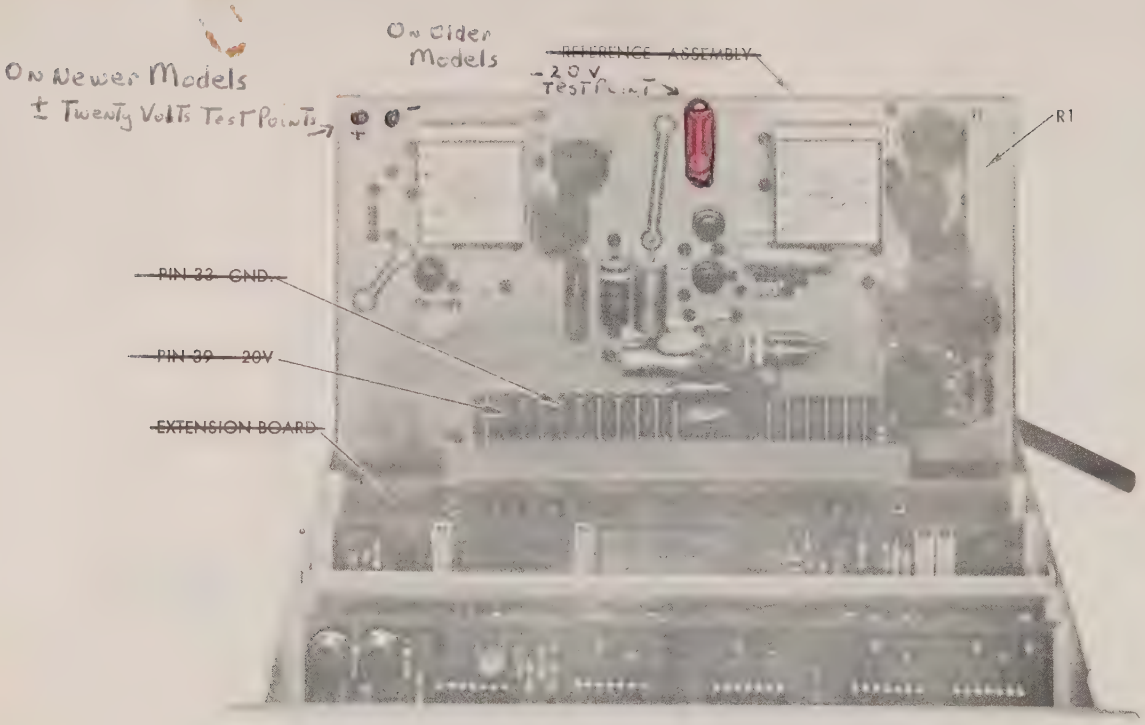


Figure 3-3. Reference Adjustment

10-Volt Range Calibration for a Negative Input Voltage

1. Reverse the connections to the voltage standard.

2. Apply approximately 9.5 volts.

3. The numerical value displayed in the readout should be equal to the voltage of the voltage standard. If it is not, adjust potentiometer R37 (Figure 3-2) of the Attenuator Assembly until the readout displays the correct value.

WARNING

Use extreme caution in performing the following steps as dangerously high voltages will be employed.

100-Volt Range Calibration

1. Place the range switch in 100 position.

2. Connect the black lead of the DVM input cable to the negative terminal of the voltage standard described in paragraph 4 under Equipment Required. Connect the red lead to the positive terminal.

3. Apply approximately 95 volts.

4. The numerical value displayed in the readout should be equal to the voltage of the voltage standard. If it is not, adjust potentiometer R5 (Figure 3-2) of the Attenuator Assembly until the readout displays the correct value.

WARNING

Use extreme caution in performing the following steps as dangerously high voltages will be employed.

1000-Volt Range Calibration

1. Place the range switch in the 1000 position.
2. Connect the black lead of the DVM input cable to the negative terminal of the voltage standard described in paragraph 5 under Equipment Required. Connect the red lead to the positive terminal.
3. Apply approximately 950 volts.
4. The numerical value displayed in the readout should be equal to the voltage standard. If it is not, adjust potentiometer R3 (Figure 3-2) of the Attenuator Assembly until the readout displays the correct value.

AC CONVERTER CALIBRATION

ADDITIONAL EQUIPMENT REQUIRED

1. An Audio Voltage Standard between 1 volt, 200 Hz - 10K Hz and 500 volts, 200 Hz - 10K Hz.

INITIAL PREPARATION

1. Ensure that the instrument is properly calibrated in the DC voltage measurement function and ensure a 30-minute warm-up period.

PROCEDURE

1. Place the function switch in the AC position.
2. Place the range switch in the 1000 position.
3. Place the power switch in the ON position.
4. Connect the red and black clips of the DVM input cable together.
5. Rotate the AC OFFSET potentiometer, R2, located on the rear of the instrument, to a position which causes the readout to display 0.000 AC.

WARNING

Use extreme caution in performing the following steps as dangerously high voltages will be employed.

CAUTION

Do not apply more than 500 VAC or damage to the AC Converter Assembly may result.

6. Connect the red lead of the DVM input cable to the AC HI terminal and the black lead to the AC LO terminal of the Audio Voltage Standard.
7. Apply approximately 450.00 volts, 200 Hz and adjust R1 (Figure 3-2) of the AC Converter Assembly until the numerical value displayed in the readout is equal to the voltage applied.
8. Apply approximately 450.00 volts, 10K Hz and adjust C1 (Figure 3-2) of the AC Converter Assembly until the numerical value displayed in the readout is equal to the voltage applied.

WARNING

Use extreme caution in performing the following steps as dangerously high voltage will be employed.

9. Place the range switch in the 100 position. Apply approximately 90.00 volts, 200 Hz and adjust R2 (Figure 3-2) of the AC Converter Assembly until the

numerical value displayed in the readout is equal to the voltage applied.

10. Apply approximately 90.00 volts 10 K Hz and adjust C2 (Figure 3-2) of the AC Converter Assembly until the numerical value displayed in the readout is equal to the voltage applied.

11. Place the range switch in the 10 position. Apply approximately 9.000 volts, 200 Hz and adjust R3 (Figure 3-2) of the AC Converter Assembly until the numerical value displayed in the readout is equal to the voltage applied.

12. Apply approximately 9.000 volts, 10K Hz and adjust C3 of the AC Converter Assembly until the numerical value displayed in the readout is equal to the voltage applied.

13. Apply approximately 0.9000 volts, 200 Hz and adjust R4 (Figure 3-2) of the AC Converter Assembly until the numerical value displayed in the readout is equal to the voltage applied.

14. Apply approximately 0.9000 volts, 10K Hz and adjust C4 (Figure 3-2) of the AC Converter Assembly until the numerical value displayed in the readout is equal to the voltage aplied.

OHMS CONVERTER AND PRE-AMPLIFIER CALIBRATION

ADDITIONAL EQUIPMENT REQUIRED

1. An ohms standard accurate to 0.01%.
2. A voltage standard between 90.00 millivolts and 119.98 millivolts.

INITIAL PREPARATION

1. Ensure that the instrument is properly calibrated in the DC voltage measurement function and ensure a 30-minute warm-up period.

PROCEDURE

1. Place the power switch in the ON position.
2. Place the range switch in the 10000 position.
3. Place the function switch in the KΩ position.
4. Connect the red and black clips of the DVM input cable together.
5. Rotate the KΩ/MV OFFSET R3 potentiometer, located on the rear of the instrument, to a position which causes the readout to display 0000 KΩ.
6. Connect the two leads of the DVM input cable to the two output terminals of the ohms standard.
7. Apply approximately 9000 KΩ and adjust R1 (Figure 3-2) of the Ohms Converter and Pre-amplifier Assembly until the numerical value displayed in the readout is equal to the ohmic value applied.
8. Place the range switch in the 100 position.
9. Place the function switch in the MV position.
10. Connect the red and black clips of the DVM input cable together.
11. Rotate the KΩ/MV OFFSET R3 potentiometer, located on the rear of the instrument, to a position which causes the readout to display 00.00 MV.
12. Connect the black lead of the DVM input cable to the negative terminal of the voltage standard described in paragraph 2 under Additional Equipment Required. Connect the red lead to the

positive terminal.

13. Apply approximately 95.00 millivolts and adjust R19 of the Ohms Converter/ Pre-amplifier Assembly (Figure 3-2) until the numerical value displayed in the readout is equal to the voltage of the voltage standard.

CHAPTER IV

MAINTENANCE

In the Series X-2 Digital Voltmeter, virtually all circuit components are assembled on plug-in modules. Thus maintenance problems are simplified to the point where the instrument can be kept operating without the need for highly trained maintenance personnel. Because of this plug-in design, downtime is held to a minimum; the unit can be kept operating in locations from which it would be impractical or inconvenient to send the instrument to a repair facility or to the manufacturer. Only a very few minutes are needed to replace all the plug-in boards. By using trial-and-error techniques the instrument can be rapidly returned to service, and the defective module repaired at a later date.

For a general understanding of the principles of operation of the Series X-2 DVM, refer to Figures 4-1 through 4-15 For a more detailed analysis, refer to the schematic and wiring diagrams at the end of this manual.

In order to pursue the plug-in philosophy to the fullest, spare modules as listed in Section V, Recommended Spare Parts List, should be kept in stock

If it is desired to measure voltages and check waveforms on a particular plug-in module, a 41-pin extension board will be required to raise the board so that pin contacts become accessible. These boards, NLS part number 1009-41, may be ordered from any NLS representative or from the NLS Main Office in Del Mar, California.

DIGITAL READOUT REPLACEMENT

The readout tubes providing the digital, polarity and function displays have exceedingly long-life expectancy and rarely require replacement. However, to replace a readout tube in the event of failure, perform the following steps:

1. Remove the cover from the instrument by removing the four screws (two on each side) attaching the cover to the chassis.
2. Remove the decade assembly (front board) from the instrument.
3. Firmly grasp the decade assembly with one hand and the malfunctioning tube with the other.
4. With a rocking motion, carefully pull the tube from its socket.
5. Install new tube, using care to properly align pins into tube socket, and replace decade board and cover in reverse order of removal.

FAN LUBRICATION

Under normal operating conditions, the ventilating fan (S/N's X-2. 157 & subsequent and those of earlier S/N's so modified) should be lubricated every two or three months.

To lubricate the fan, remove the blue slotted plug from rear of fan assembly and apply two or three drops of Rotron M-21 lubricant.

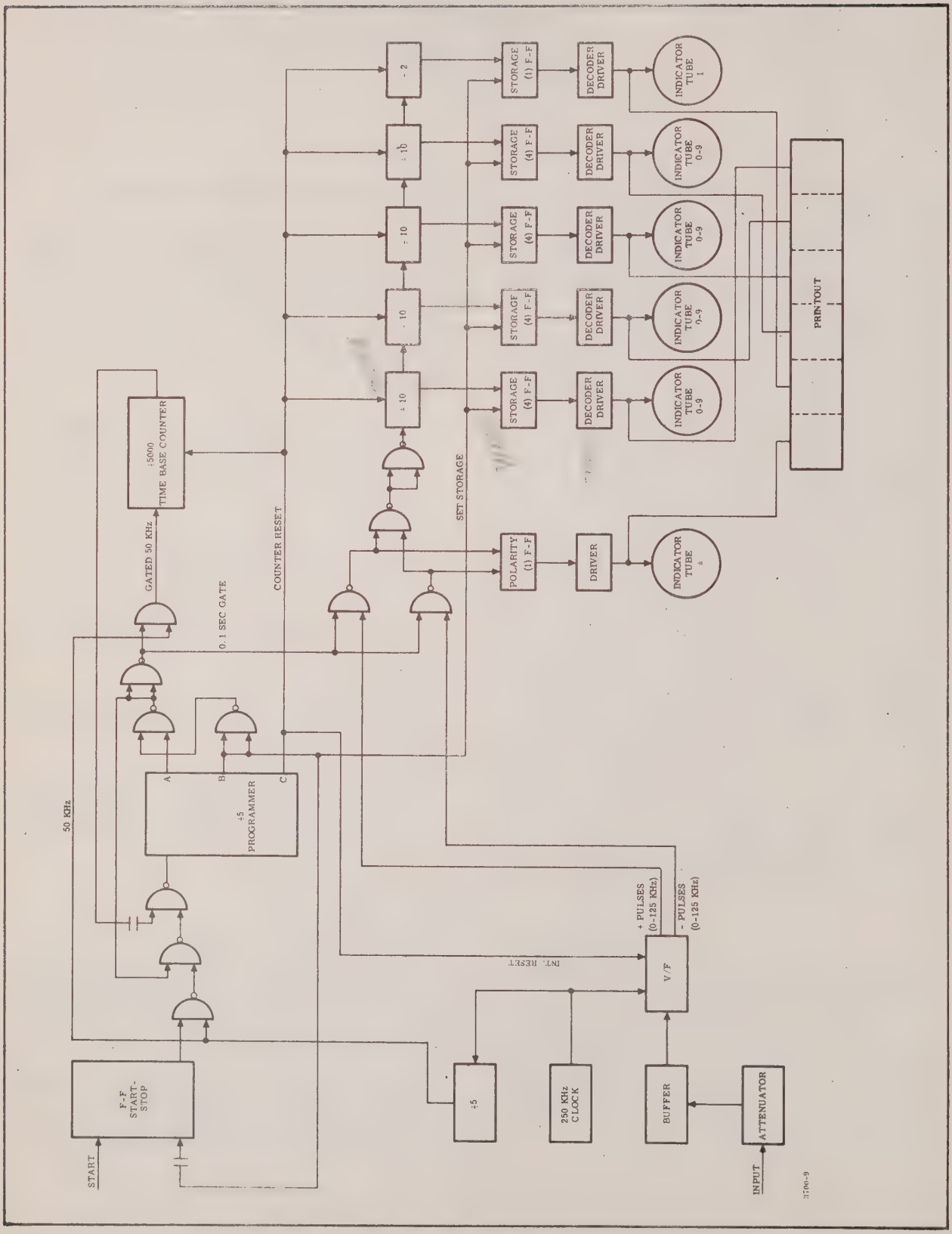


Figure 4-1. Block Diagram Series X-2 DVM

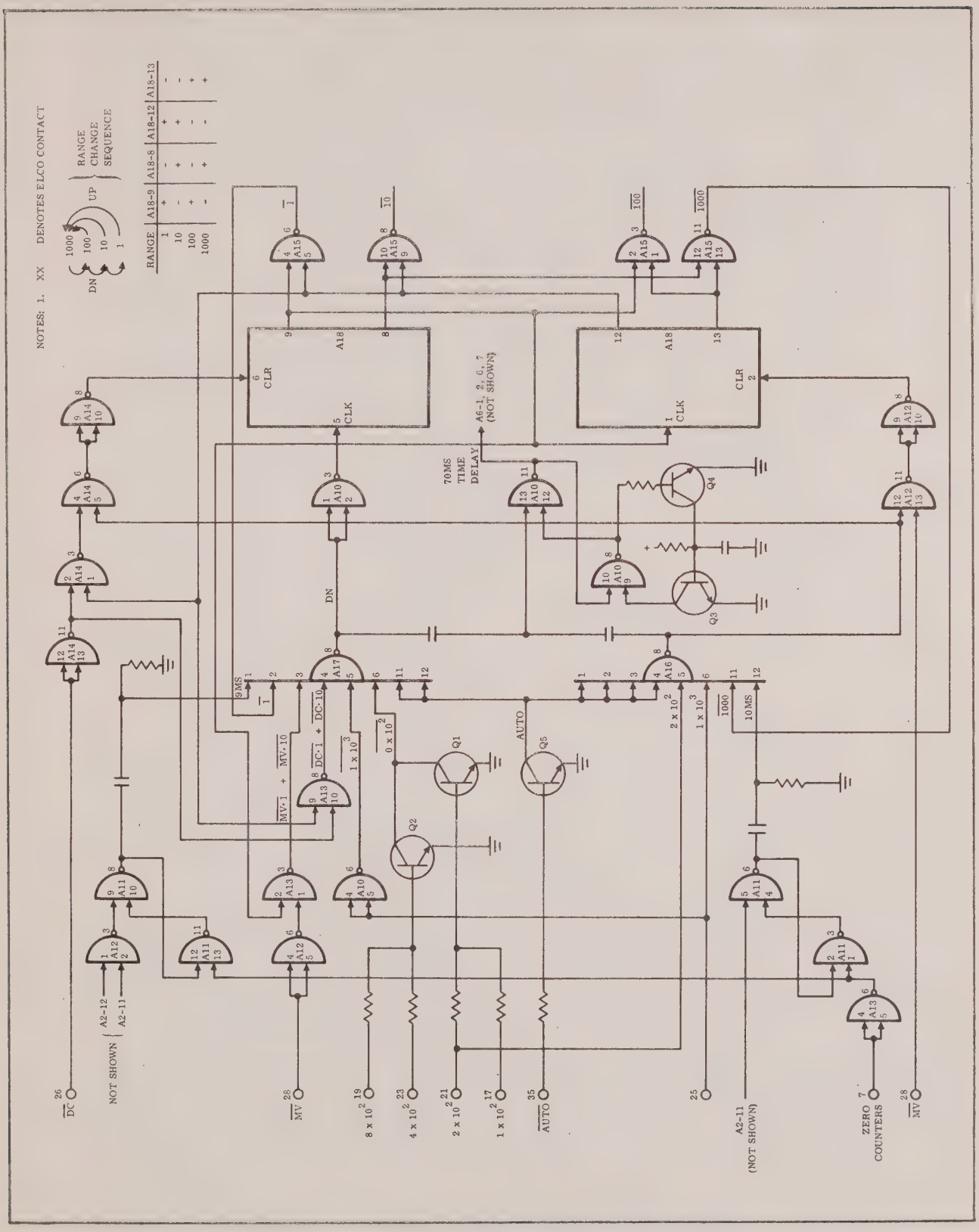


Figure 4-2. Simplified Diagram, Auto-ranging

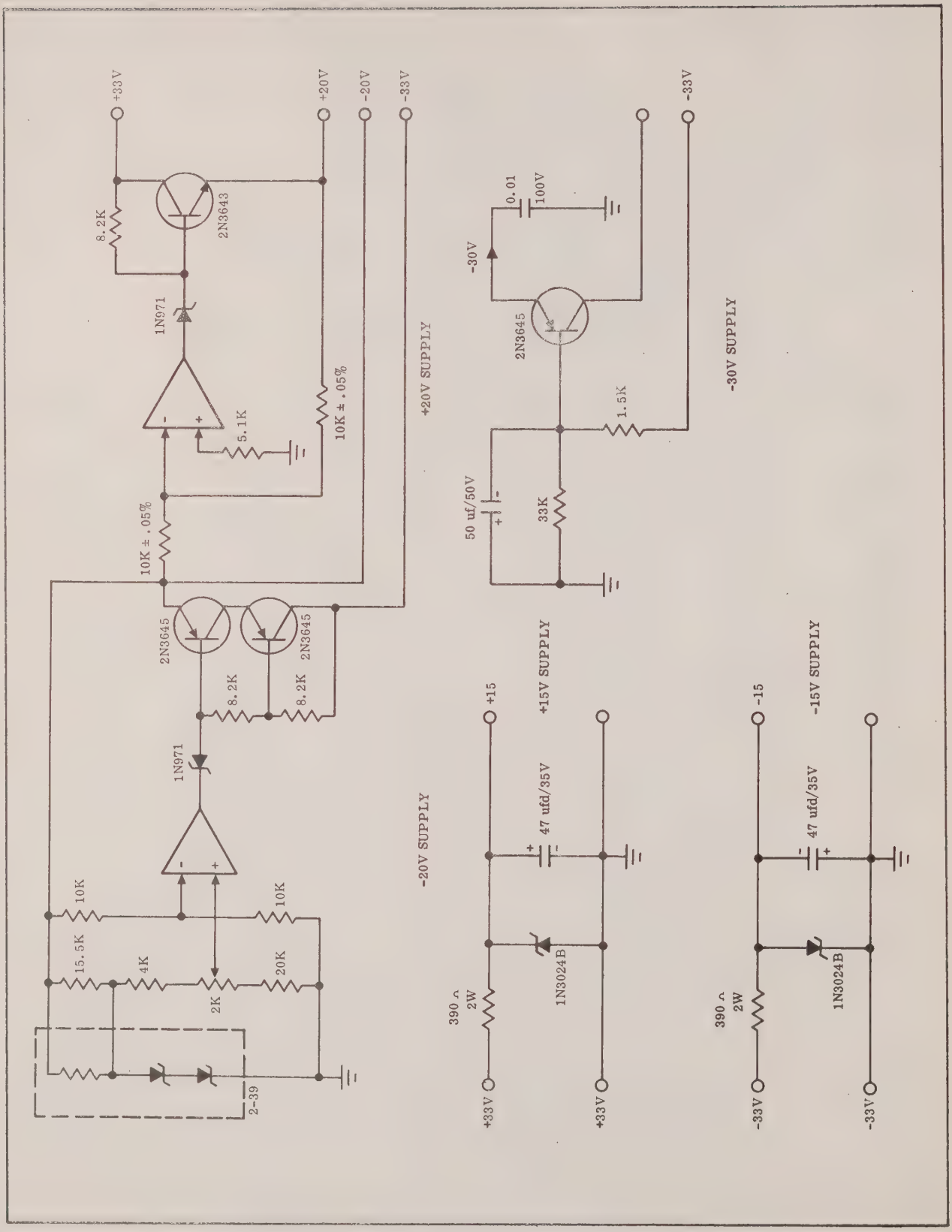


Figure 4-3. Simplified Diagram, Reference Supply

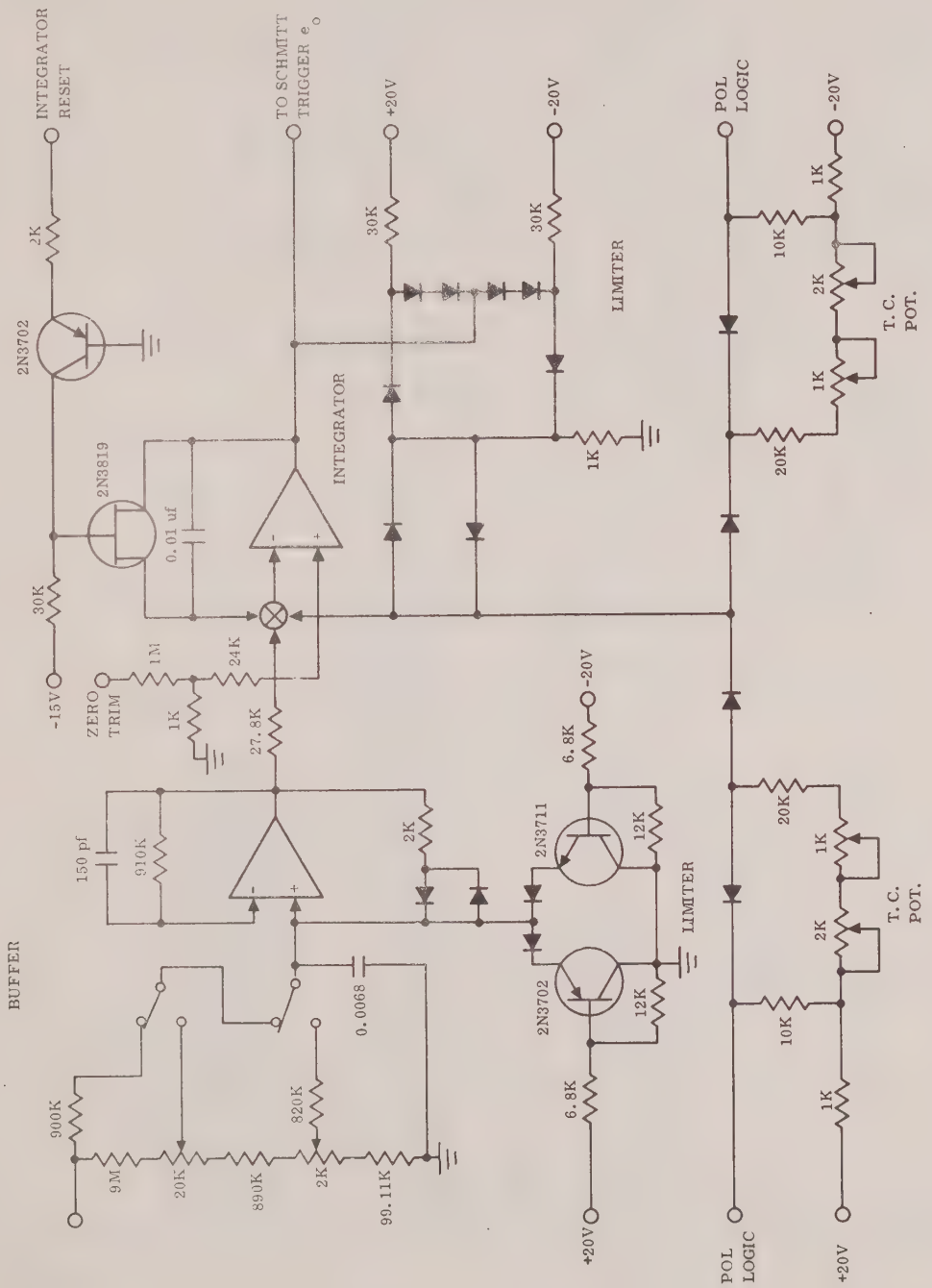
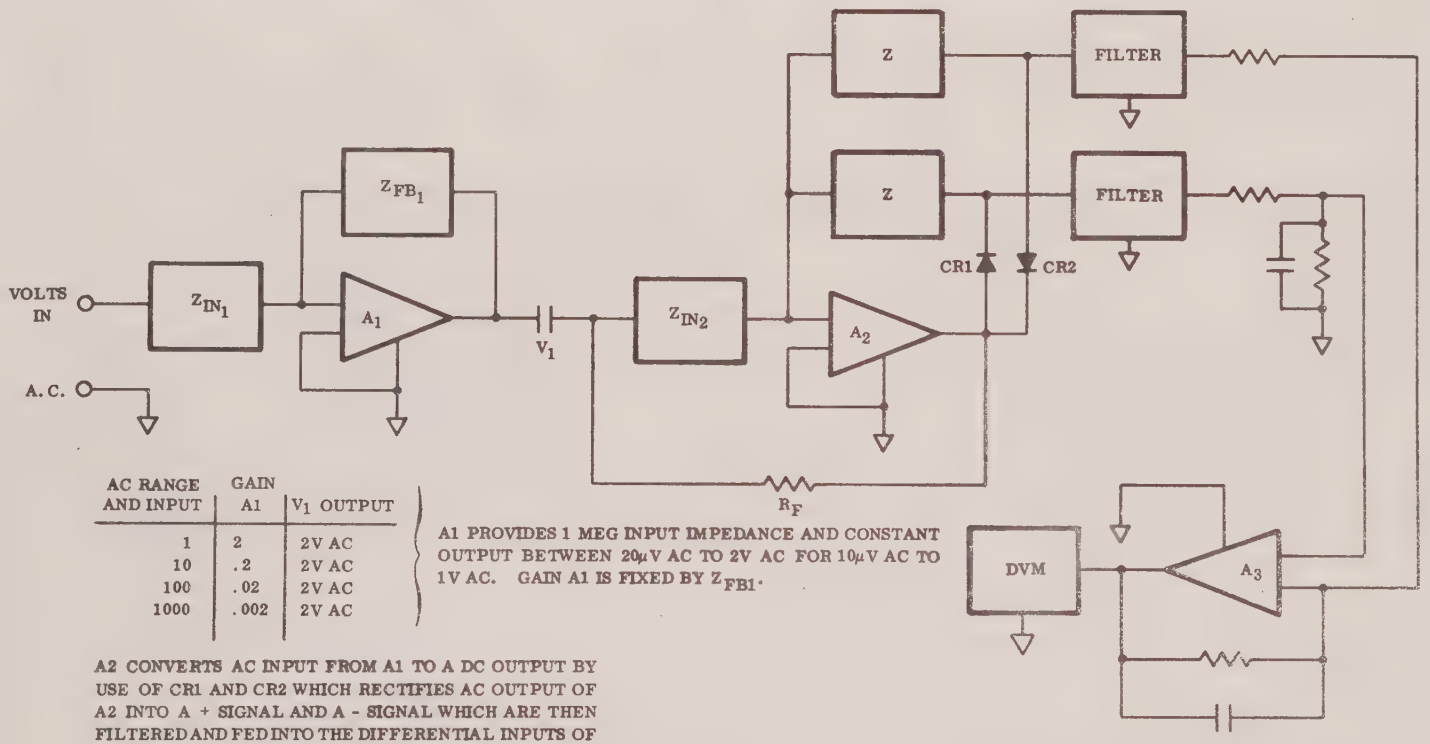


Figure 4-4. Simplified Diagram, Series X-2 Input - Integrator with Resetter Circuitry and Temperature Compensation Potentiometers



AC RANGE AND INPUT	GAIN A1	V_1 OUTPUT
1	2	2V AC
10	.2	2V AC
100	.02	2V AC
1000	.002	2V AC

A1 PROVIDES 1 MEG INPUT IMPEDANCE AND CONSTANT OUTPUT BETWEEN 20μV AC TO 2V AC FOR 10μV AC TO 1V AC. GAIN A1 IS FIXED BY Z_{FB1}.

A2 CONVERTS AC INPUT FROM A1 TO A DC OUTPUT BY USE OF CR1 AND CR2 WHICH RECTIFIES AC OUTPUT OF A2 INTO A + SIGNAL AND A - SIGNAL WHICH ARE THEN FILTERED AND FED INTO THE DIFFERENTIAL INPUTS OF A3. A3 PUTS AN OUTPUT IN THE RANGE OF THE DVM (10μV TO 10 VOLTS DC).

3600-26

Figure 4-5. Simplified Diagram AC Converter

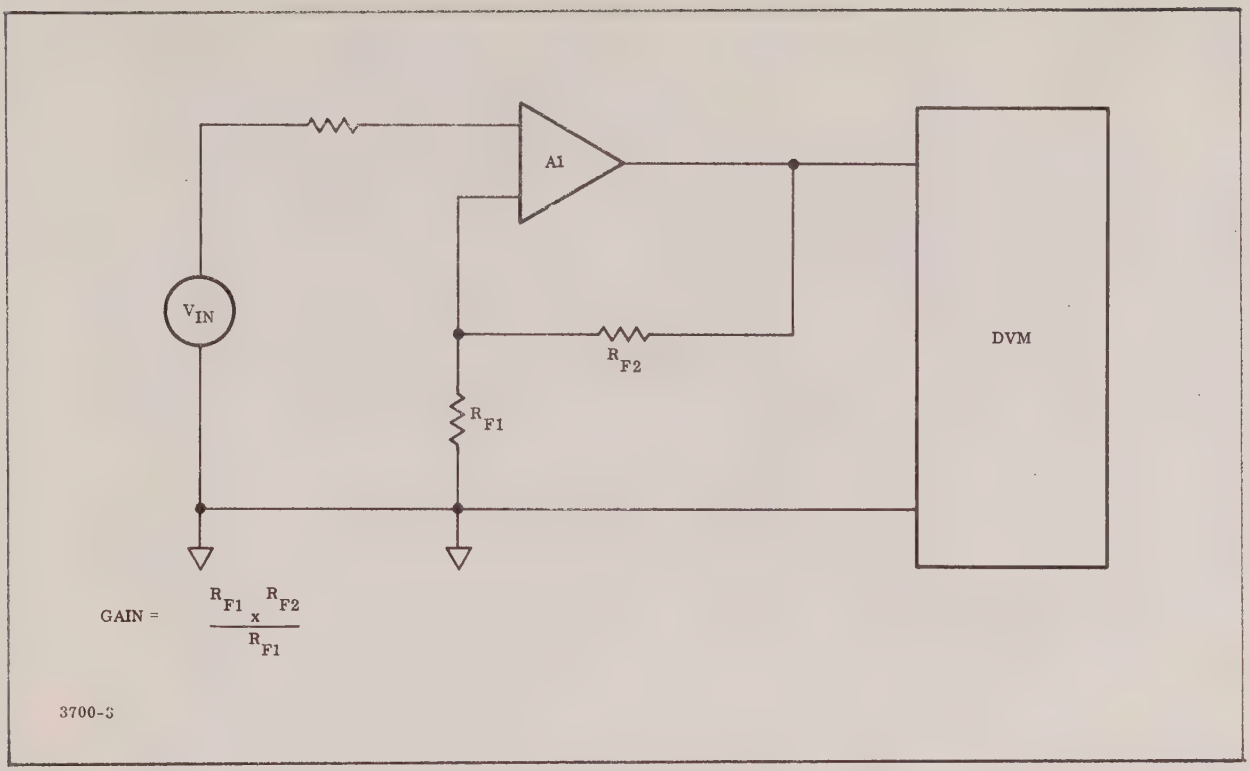
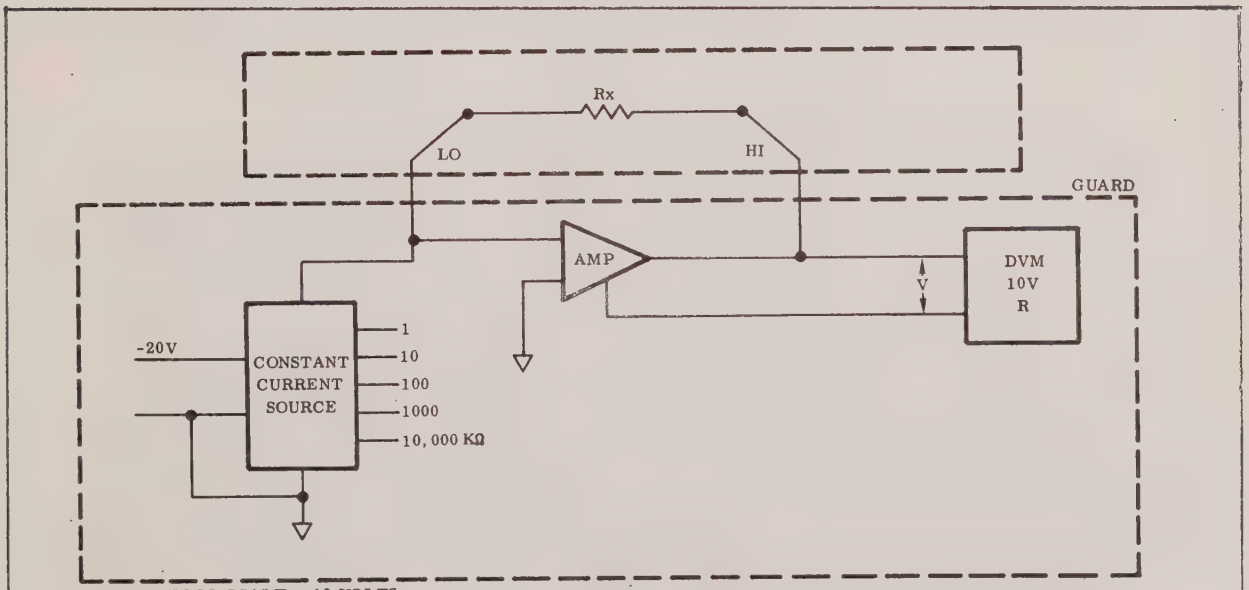


Figure 4-6. Simplified Diagram Pre-amplifier



R_X	I
1K	10MA
10K	1MA
100K	100μA
1000K	10μA
10,000K	1μA

Figure 4-7. Simplified Diagram Ohms Converter

TRUTH TABLES

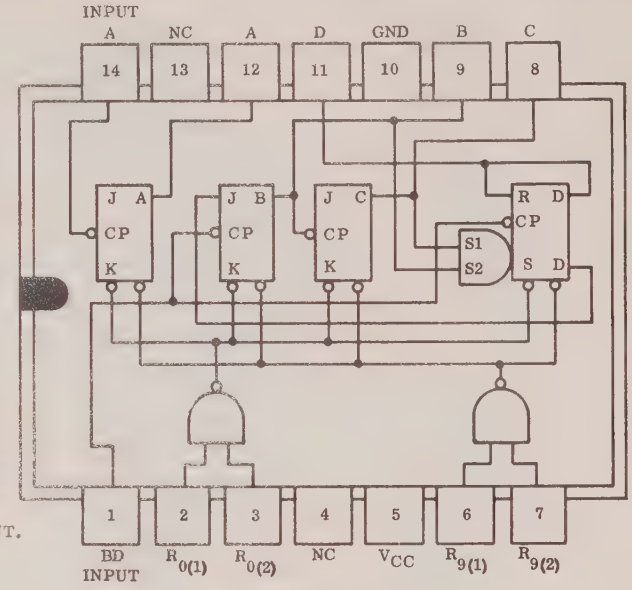
BCD COUNT SEQUENCE
(SEE NOTE 1)

COUNT	OUTPUT			
	D	C	B	A
0	0	0	0	0
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	0	0
5	0	1	0	1
6	0	1	1	0
7	0	1	1	1
8	1	0	0	0
9	1	0	0	1

RESET/COUNT (SEE NOTE 2)

RESET INPUTS				OUTPUT
$R_{0(1)}$	$R_{0(2)}$	$R_{9(1)}$	$R_{9(2)}$	D C B A
1	1	0	X	0000
1	1	X	0	0000
X	0	1	1	1001
0	X	1	1	1001
1	1	1	1	1001
X	0	X	0	COUNT
0	X	0	X	COUNT
0	X	X	0	COUNT
X	0	0	X	COUNT

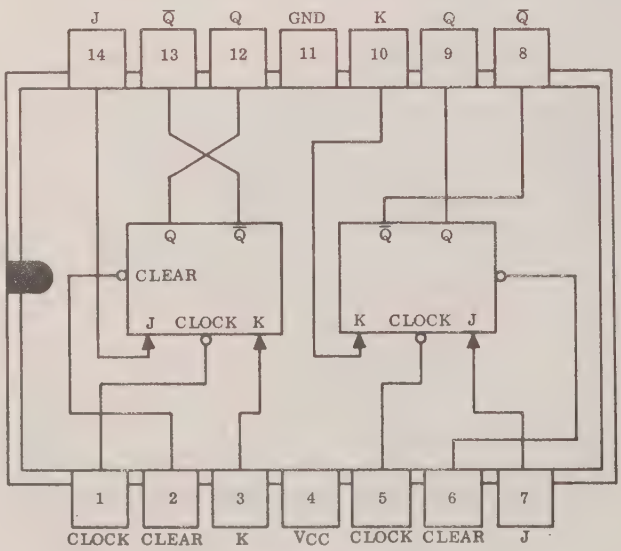
NOTES:
1. OUTPUT A CONNECTED TO INPUT BD FOR BCD COUNT.
2. X INDICATES THAT EITHER A LOGICAL 1 OR A LOGICAL 0 MAY BE PRESENT.



POSITIVE LOGIC
SEE TRUTH TABLES
NC–NO INTERNAL CONNECTION

3700-10

Figure 4-8. Type SN7490N Decade Counter



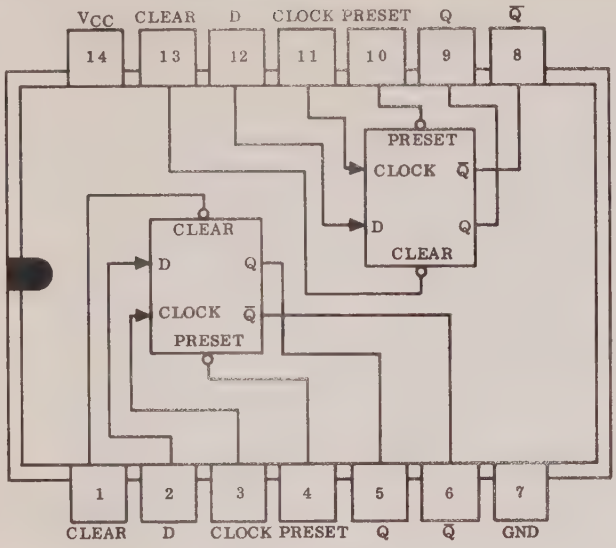
POSITIVE LOGIC
LOW INPUT TO CLEAR SETS Q TO LOGICAL 0
REGARDLESS OF CLOCK STATE.

3700-11

TRUTH TABLE (EACH FLIP-FLOP)		
t_n		$t_n + 1$
J	K	Q
0	0	Q_n
0	1	0
1	0	1
1	1	$\overline{Q}_n$

NOTES:
1. t_n = BIT TIME BEFORE CLOCK PULSE.
2. $t_n + 1$ = BIT TIME AFTER CLOCK PULSE.

Figure 4-9. Type SN7473N Dual J-K Master-Slave Flip-Flop



POSITIVE LOGIC

a. LOW INPUT TO CLEAR SETS Q TO LOGICAL 0.
b. LOW INPUT TO PRESET SETS Q TO LOGICAL 1.
c. CLEAR OR PRESET INPUTS DOMINATE REGARDLESS OF CLOCK AND D INPUTS.

3700-12

TRUTH TABLE (EACH FLIP-FLOP)

t_n	$t_n + 1$	
INPUT D	OUTPUT Q	OUTPUT $\bar{Q}$
0	0	1
1	1	0

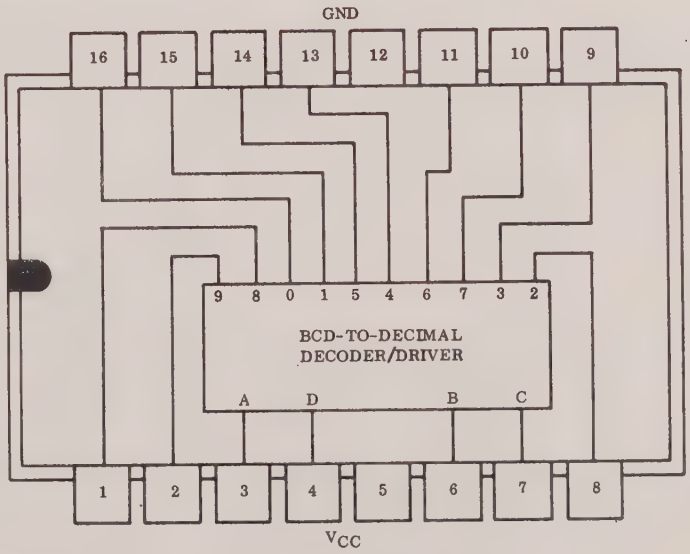
NOTES:
1. t_n = BIT TIME BEFORE CLOCK PULSE.
2. $t_n + 1$ = BIT TIME AFTER CLOCK PULSE.

Figure 4-10. Type SN7474N Dual D-Type Edge-Triggered Flip-Flop

TRUTH TABLE

INPUT				OUTPUT ON ‡
D	C	B	A	
0	0	0	0	0
0	0	0	1	1
0	0	1	0	2
0	0	1	1	3
0	1	0	0	4
0	1	0	1	5
0	1	1	0	6
0	1	1	1	7
1	0	0	0	8
1	0	0	1	9

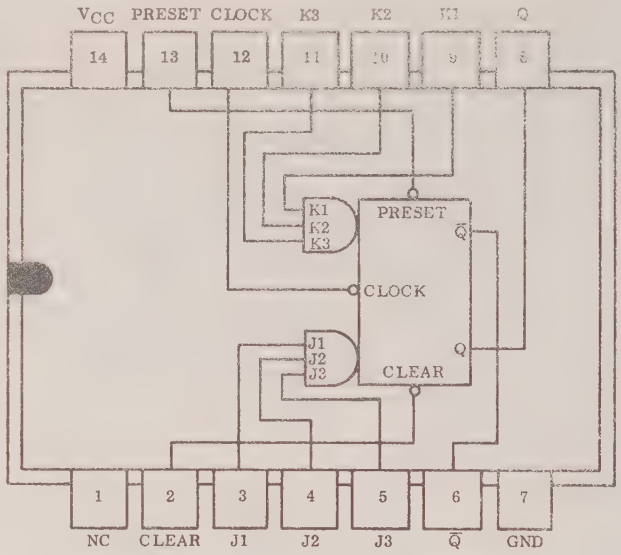
‡ ALL OTHER OUTPUTS ARE OFF.



3700-13

POSITIVE LOGIC
SEE TRUTH TABLE

Figure 4-11. Type SNX7441N BCD-to-Decimal Decoder/Driver



POSITIVE LOGIC
LOW INPUT TO PRESET SETS Q TO LOGICAL 1
LOW INPUT TO CLEAR SETS Q TO LOGICAL 0

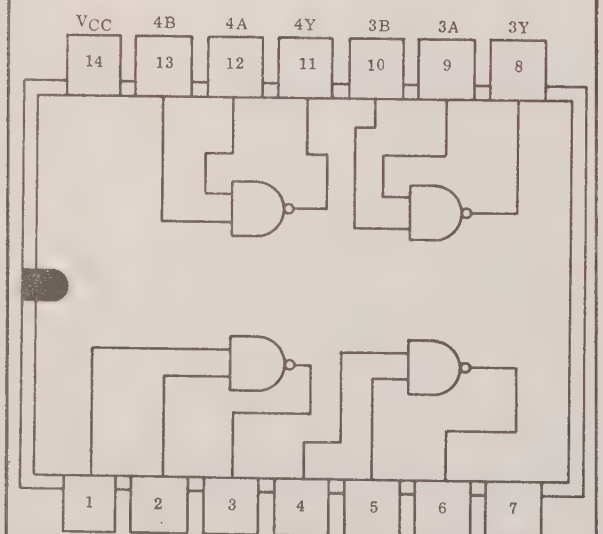
TRUTH TABLE		
t_n		$t_n + 1$
J	K	Q
0	0	Q_n
0	1	0
1	0	1
1	1	$\overline{Q}_n$

NOTES: 1. $J = J1 \cdot J2 \cdot J3$
2. $K = K1 \cdot K2 \cdot K3$
3. t_n = BIT TIME BEFORE CLOCK PULSE.
4. $t_n + 1$ = BIT TIME AFTER CLOCK PULSE.

NC–NO INTERNAL CONNECTION.

3700-14

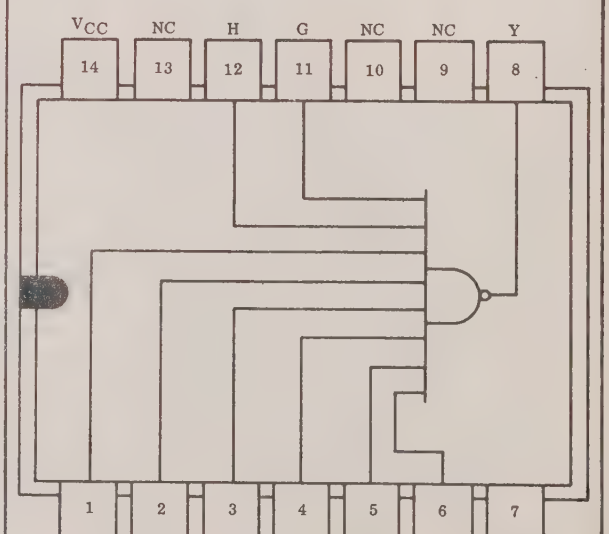
Figure 4-12. Type SN7470N JK Master-Slave Flip-Flop



POSITIVE LOGIC
$Y = \overline{AB}$

3700-15

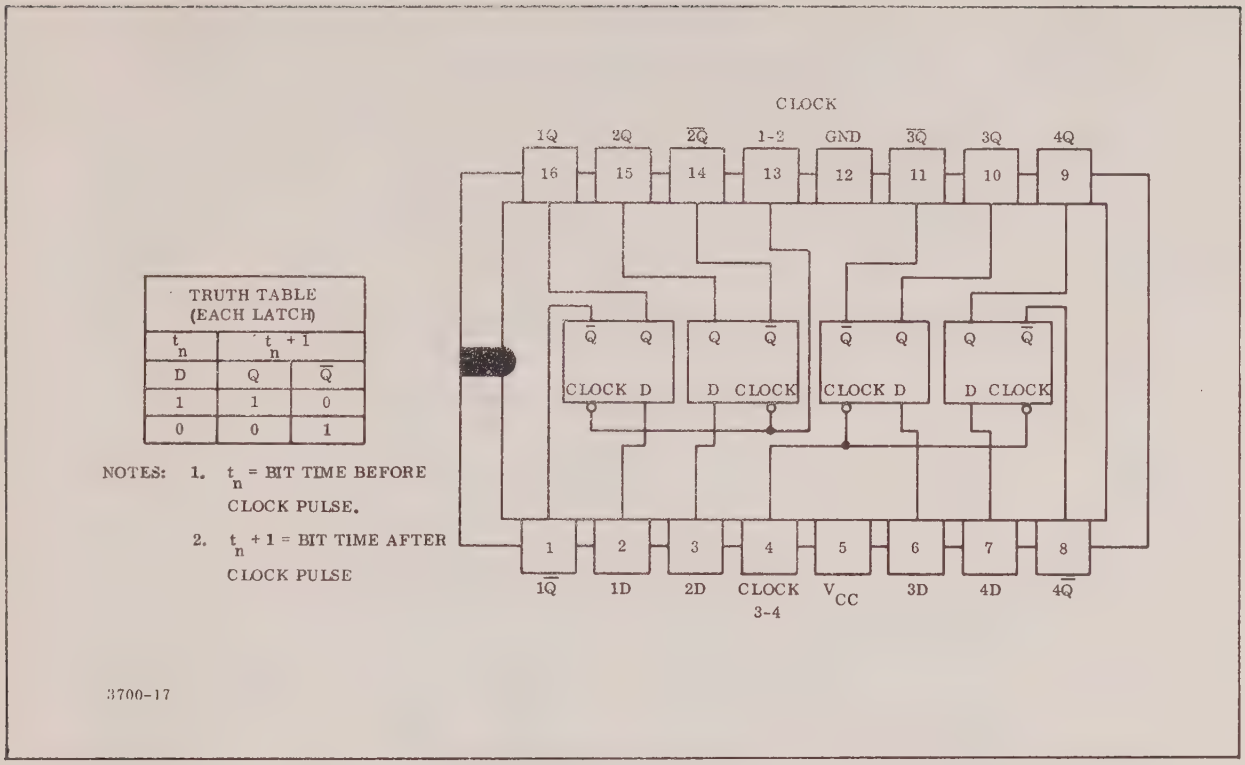
Figure 4-13. Type SN7400N Quadruple 2-Input Positive Nand Gate



POSITIVE LOGIC
$Y = \overline{ABCDEFGH}$

3700-16 NC–NO INTERNAL CONNECTION

Figure 4-14. Type SN7430N 8-Input Positive Nand Gate



TRUTH TABLE (EACH LATCH)		
t_n	$t_n + 1$	
D	Q	$\overline{Q}$
1	1	0
0	0	1

NOTES: 1. t_n = BIT TIME BEFORE CLOCK PULSE.

2. $t_n + 1$ = BIT TIME AFTER CLOCK PULSE

3700-17

Figure 4-15. Type SN7475N Quadruple Bistable Latch

CHAPTER V

RECOMMENDED SPARE PARTS LIST

Part No.	Description	Qty.
37-30	Decade Assembly (S/N's X-2. 1 thru X-2. 301)	1
37-36	Reference Assembly	1
37-39	Attenuator Assembly	1
37-69	Start-Stop Assembly*	1
37-160	Decade Assembly (S/N's X-2. 302 & Subsequent)	1
SP2A2	Fan Assembly	1
31300. 5	Fuse, 3AG0.5A, Slo-Blo	6
1009-41	Extension Board (Test Equipment)	1

*If instrument has auto ranging capability, substitute 37-33, Auto-Range and Start-Stop Assembly.

APPENDIX

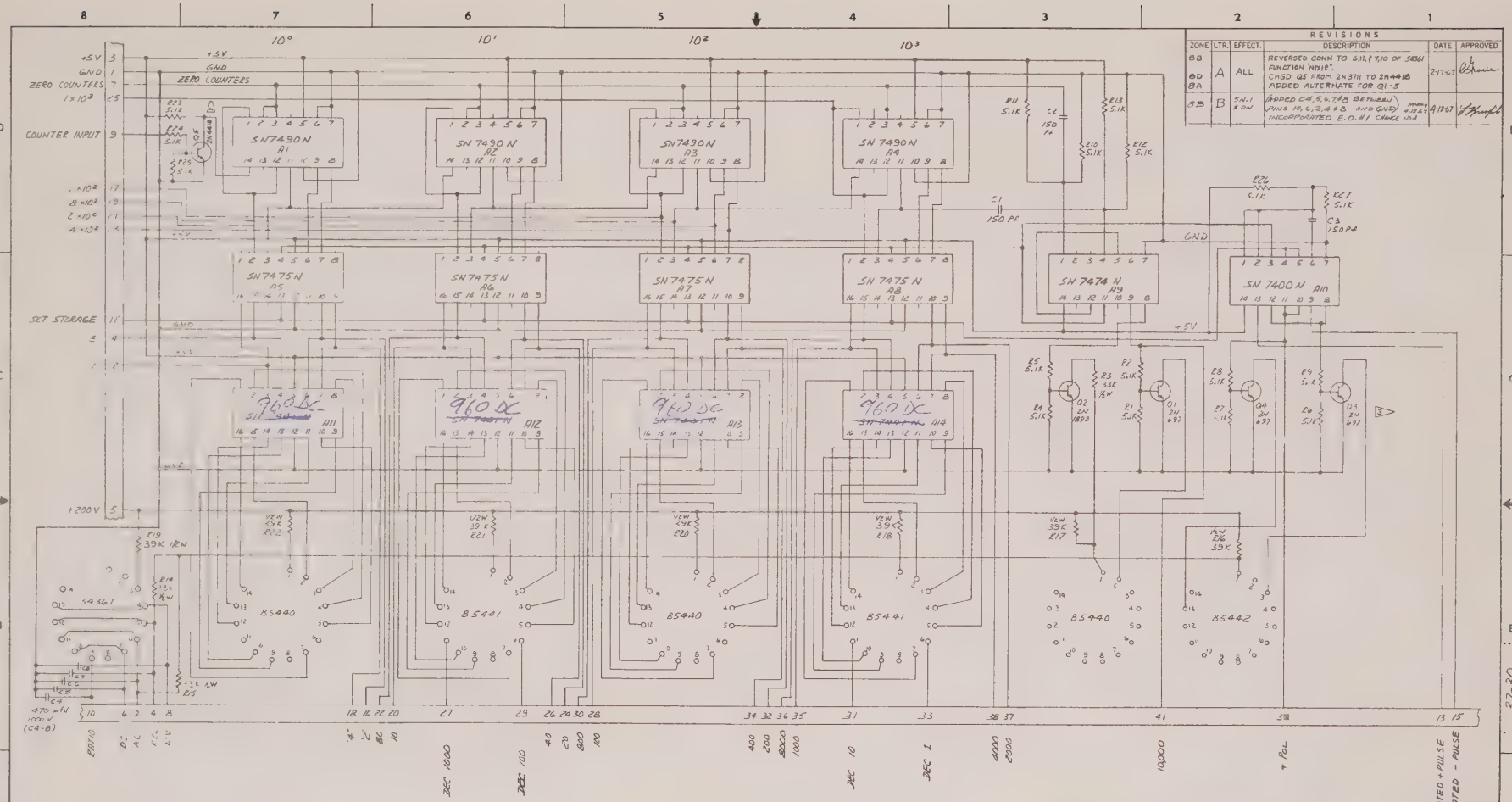
SHIPPING INSTRUCTIONS

Depending upon location, the choice of carrier will vary. Never ship an instrument to us without having received shipping instructions. If requested, an estimate of charges can be made before work begins.

Be certain to pack the instrument carefully; while an outer and inner box, separated by two or three inches of excelsior is desirable, the instrument can be placed into a single container provided it is so packed that it will not shift about. As with the double box method, use two or three inches of shock-absorbent packing materials. The instrument itself should be first wrapped in heavy paper so as to keep excelsior or other particles from entering the instrument's louvers. If the original shipping container is in good condition, it may be used.

CLAIM FOR DAMAGE IN SHIPMENT

The instrument should be tested as soon as it is received. If it does not operate or is damaged, a claim should be made with the carrier. The claim agent should receive a full report of damage, and this report sent to Non-Linear Systems, Inc. After receiving such a report we will advise you of the disposition of the instrument and arrange for its repair or replacement. Be certain to include model and serial number when corresponding.



REVISIONS					
ZONE	LTR.	EFFECT.	DESCRIPTION	DATE	APPROVED
8B 8D 8A	A	ALL	REVERSED CONN TO 6,11 & 7,10 OF 5826 FUNCTION "NINE". CHGD Q5 FROM 2N3711 TO 2N4416 ADDED ALTERNATE FOR Q1-5	2-17-67	
8B	B	SN.1 X ON	ADDED C4, 5, 6, 7 & 8 BETWEEN (PINS 10, 6, 2, 4 & 8 AND GND) INCORPORATED E.O. #1 CHANGE N/A	4-13-67 APPROV. 4-13-67	A1367

NOTE: THIS DRAWING EFFECTIVE S/N's X-2. 1 THRU X-2. 150.

1. REFERENCE DESIGNATIONS ARE ABBREVIATED. PREFIX WITH ASSEMBLY DESIGNATION SHOWN ON SHEET 2 OF FINAL ASSEMBLY.

2. Q5 ALTERNATE: 2N2368 T.I.

3. Q1-4 ALTERNATE: A-133, AMPEREX

QTY. REQD	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MFR. CODE	CIRCUIT REF.	ITEM NO.

PARTS LIST

UNLESS OTHERWISE SPECIFIED	CONTR. NO	
DIMENSIONS ARE IN INCHES TOLERANCES ON DECIMALS ± .010 ANGLES ± 0° 30' FRACTIONS ± 1/32	DRAWN	1-10-67
	CHECK	2-18-67
	APPR	2-10-67
	RELEASE DATE	2-15-67
MATERIAL		

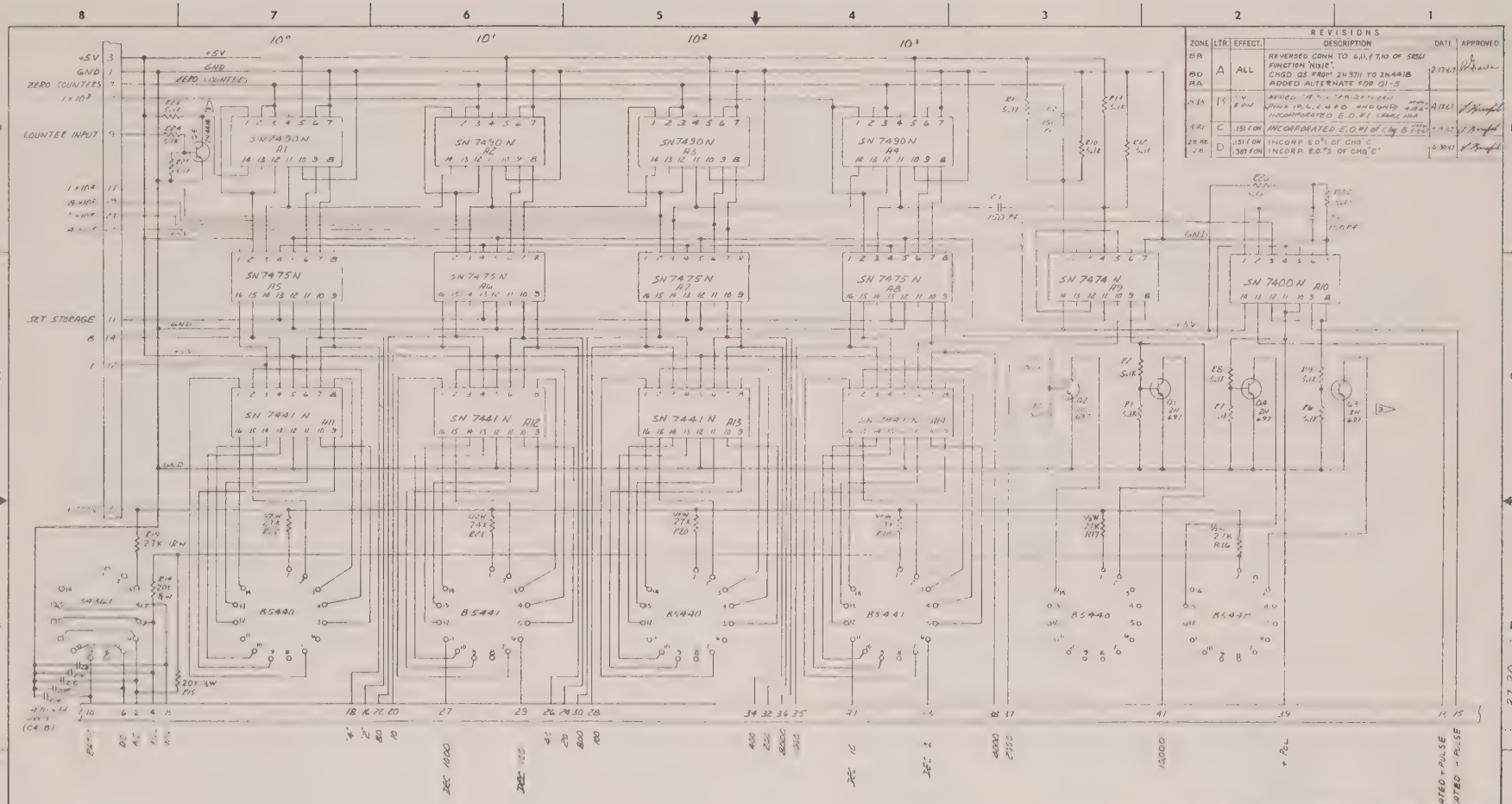
NON-LINEAR SYSTEMS, INC.
DEL MAR, CALIFORNIA

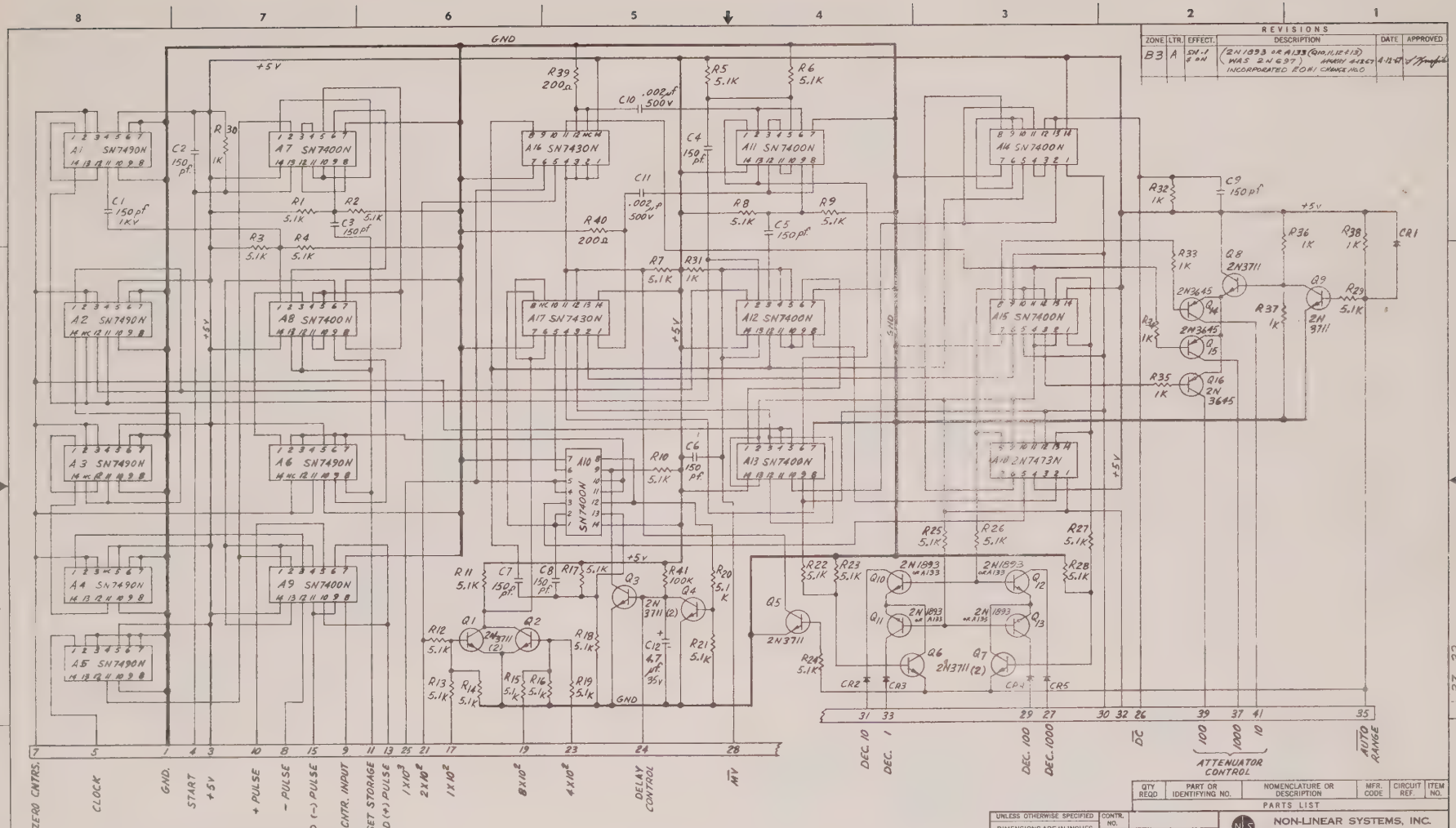
SCHEMATIC - DECADE
SERIES X-2

SIZE	CODE IDENT NO.	37-30
D	03626	
SCALE	WEIGHT	SHEET 2 OF 3

37-2 NEXT ASSY	37-2 FINAL ASSY.	1 NEXT ASSY	1 FINAL ASSY
APPLICATION		QTY.	

37-30 SH 2


REVISIONS
ZONE | LTR | EFFECT | DESCRIPTION | DATE | APPROVED
BB BD BA | A | ALL | REVERSED CONN TO 6,11,7,10 OF SN41 FUNCTION "NIXIE". CHGD Q5 FROM 2N3711 TO 2N4418 ADDED ALTERNATE FOR Q1-5 | 2-17-67
BB | B | +V & ON | ADDED 14 V., 7.9 Ω RES. PINS 10, 6, 2, 4 & 8 AND GND. INCORPORATED E.O. #1 CHG. NO. A | A-13-67
BA | C | .151 ON | INCORPORATED E.O. #1 of Chg B | 9-6-67
BB BA | D | .131 ON .301 ON | INCORP. E.O. #1 OF CHG "C" INCORP. E.O. #2 OF CHG "C" | 6-30-71
+5V
GND
ZERO COUNTERS
1 × 10³
COUNTER INPUT
1 × 10²
8 × 10¹
4 × 10⁰
2 × 10⁰
1 × 10⁰
SET STORAGE
10⁰
10¹
10²
10³
SN7490N A1
SN7490N A2
SN7490N A3
SN7490N A4
SN7475N A5
SN7475N A6
SN7475N A7
SN7475N A8
SN7441N A11
SN7441N A12
SN7441N A13
SN7441N A14
SN7474N A9
SN7400N A10
B5440
B5441
Q1-4 ALTERNATE: A-139 AMPEREX
Q5 ALTERNATE 2N2368 T1
NOTE: THIS DRAWING EFFECTIVE S/N's X-2. 151 thru X-2. 301.
PARTS LIST
QTY REQD | PART OR IDENTIFYING NO. | NOMENCLATURE OR DESCRIPTION | MFR CODE | CIRCUIT REF | ITEM NO.
NON-LINEAR SYSTEMS, INC.
DEL MAR, CALIFORNIA
SCHEMATIC - DECADE SERIES X-2
SIZE D | DRAWING NO 03626 | 37-30
SHEET 2 OF 3



REVISIONS					
ZONE	LTR.	EFFECT.	DESCRIPTION	DATE	APPROVED
B3	A	SH-1 & SH	(2N1893 OR A133 (Q10,11,12 & 13) WAS 2N697) ADDED 4/28/67 INCORPORATED ECN#1 CHANGE NO. 0	4-12-67	

2 DIODES ARE NLS 5003-002.
1. RESISTORS ARE ¼W, 5% CARBON.

NOTES: UNLESS OTHERWISE SPECIFIED

QTY REQD	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MFR. CODE	CIRCUIT REF.	ITEM NO.

PARTS LIST

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON
DECIMALS ± .010
FRACTIONS ± 1/32
ANGLES ± 0° 30'

CONTR. NO.

DRAWN	WICKLAND	1-31-67
CHECK		2-13-67
APPR		2-13-67
RELEASE DATE		2-13-67

MATERIAL

NEXT ASSY.	FINAL ASSY.	NEXT ASSY.	FINAL ASSY.
APPLICATION		QTY.	

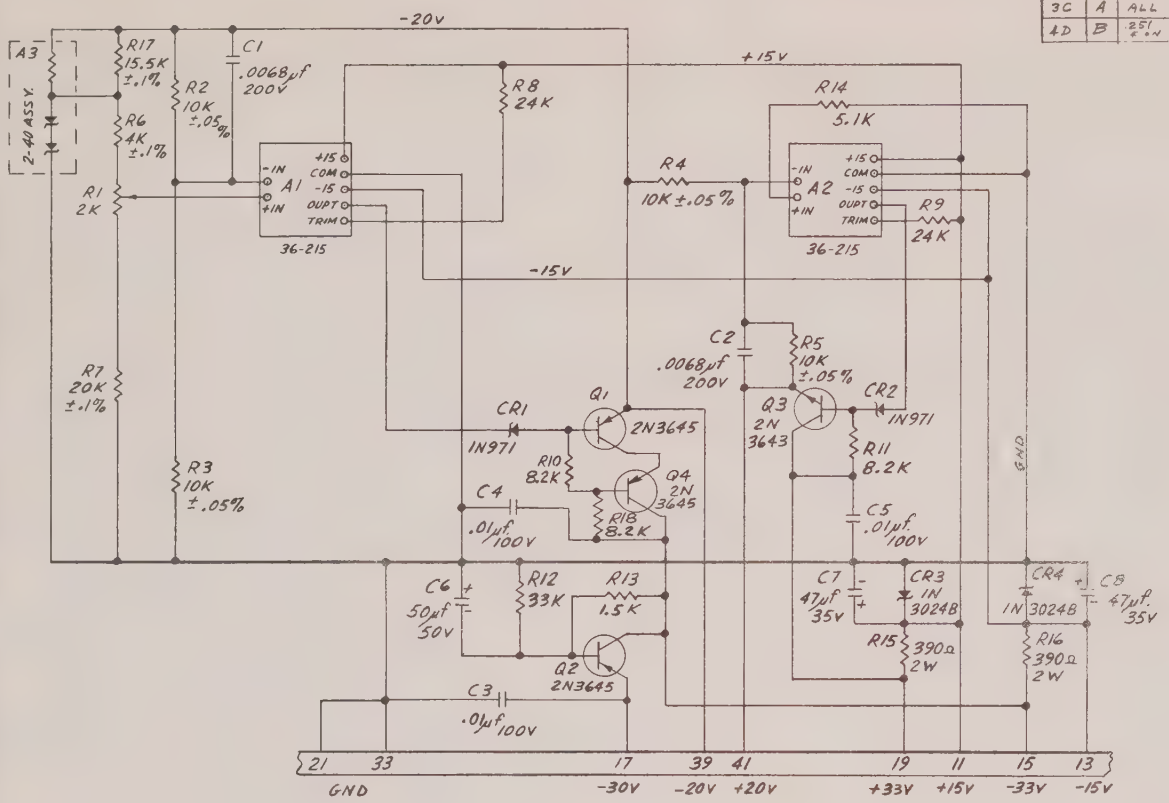
NON-LINEAR SYSTEMS, INC.
DEL MAR, CALIFORNIA

START / STOP & AUTO RANGE ASSEMBLY

X 2

SIZE	CODE IDENT NO.	
D	03626	37-33

SCALE | WEIGHT | SHEET 2 OF 3



REVISIONS					
ZONE	LTR.	EFFECT.	DESCRIPTION	DATE	APPROVED
3C	A	ALL	ADDED Q4 & R18 R.D.W.	4-23-67	RWJ
4D	B	251 & ON	A3 (2-40 ASSY) WAS 2-39 ASSY.	5-8-67 WCS	

37-36 SH2

QTY REQD	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MFR. CODE	CIRCUIT REF.	ITEM NO.

PARTS LIST

3 REFERENCE DESIGNATIONS ARE ABBREVIATED. PREFIX WITH ASSEMBLY DESIGNATION SHOWN ON SHEET 2 OF FINAL ASSEMBLY

2. RESISTORS R2 THRU R7 & R17 ARE NLS PW2016.

1. RESISTORS ARE 1/4 W, ±5%, CARBON.

NOTES: UNLESS OTHERWISE SPECIFIED

37-2	37-2	1	1
NEXT ASSY.	FINAL ASSY.	NEXT ASSY.	FINAL ASSY.
APPLICATION		QTY.	

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON
DECIMALS ± .010
ANGLES ± 0° 30'
FRACTIONS ± 1/32

MATERIAL

CONTR. NO.

DRAWN	WICKLAND	2-1-67
CHECK		2-16-67
APPR	R Jones	2-16-67
RELEASE DATE		

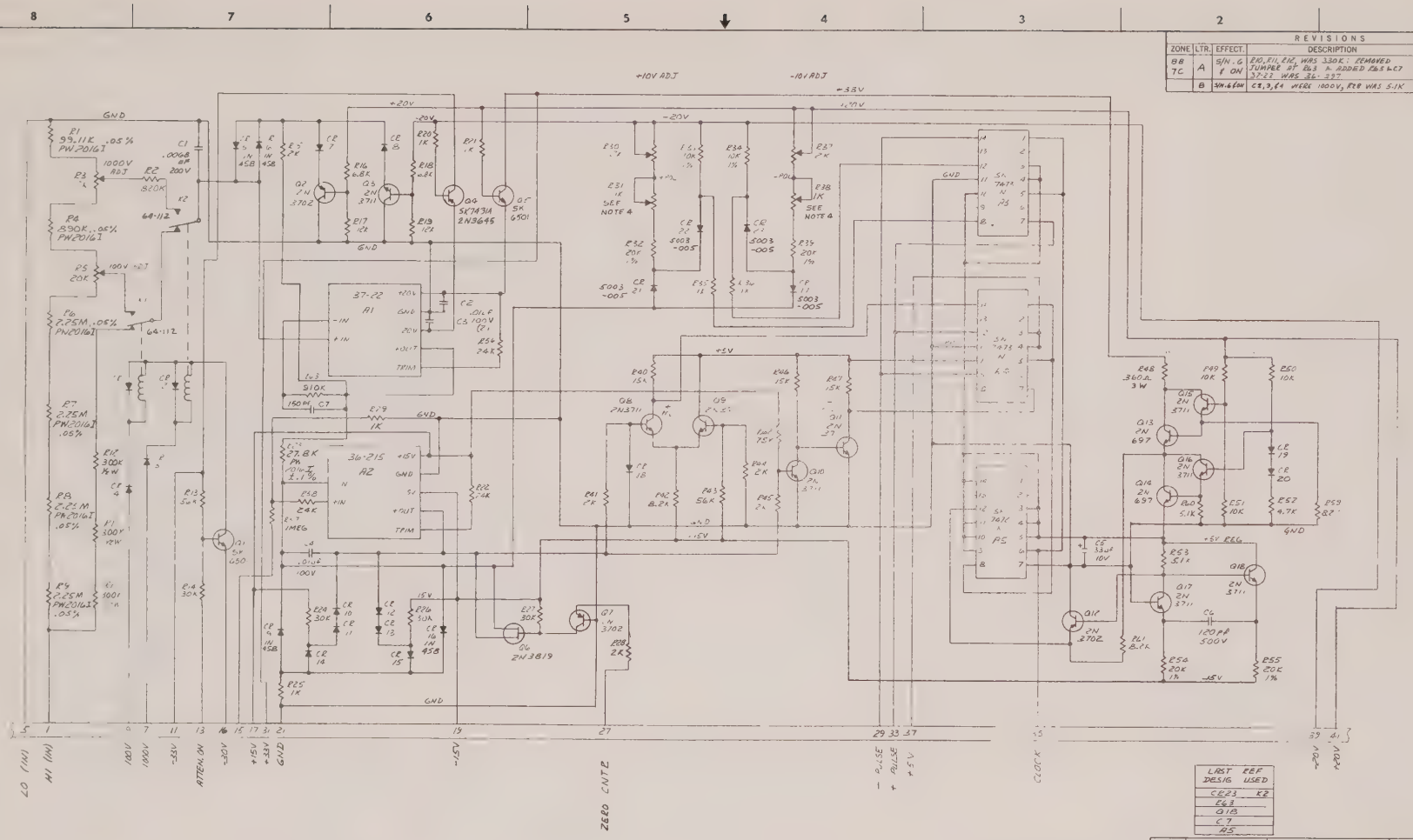
NON-LINEAR SYSTEMS, INC.
DEL MAR, CALIFORNIA

-SCHEMATIC-
REFERENCE ASSEMBLY
X2

SIZE	CODE IDENT NO.	
C	03626	37-36

SCALE | WEIGHT | SHEET 2 OF 3

8/66 DIETZGEN POST CLEARPRINT 1000H 10



REVISIONS					
ZONE	LTR.	EFFECT.	DESCRIPTION	DATE	APPROVED
8B 7C	A	S/N 1 & ON	E10, E11, E12, WAS 330K; REMOVED JUMPER AT E13 & ADDED E63 & C7 37-22 WAS 36-227	2-27-67	
	B	S/N 66 & ON	C23, 24, 64 WERE 1000V, R28 WAS 5.1K	3-1-67 REV. W	3-7-67

LAST REF DESIG	USED
CR23	K2
E63	
Q18	
C7	
R5	

QTY REQD	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MFR. CODE	CIRCUIT REF.	ITEM NO.

PARTS LIST

4. FOR TEMPERATURE COMPENSATION ADJUSTMENT OF R31 & R38 SEE DOC. # 833
3. [illegible] ARE ABBREVIATED. PREFIX WITH [illegible] DESIGNATION SHOWN ON SHEET 2 OF FINAL ASSEMBLY
2. ALL DIODES NLS 5003-002
1. ALL RES ¼W, 5%

NOTES. UNLESS OTHERWISE SPECIFIED

UNLESS OTHERWISE SPECIFIED	CONTR. NO.	
DIMENSIONS ARE IN INCHES TOLERANCES ON DECIMALS ± .010 ANGLES ± 0° 30' FRACTIONS ± 1/32	DRAWN	1-20-67
	CHECK	2-27-67
	APPR	2-27-67
	RELEASE DATE	2-27-67
MATERIAL		

NON-LINEAR SYSTEMS, INC.
DEL MAR, CALIFORNIA

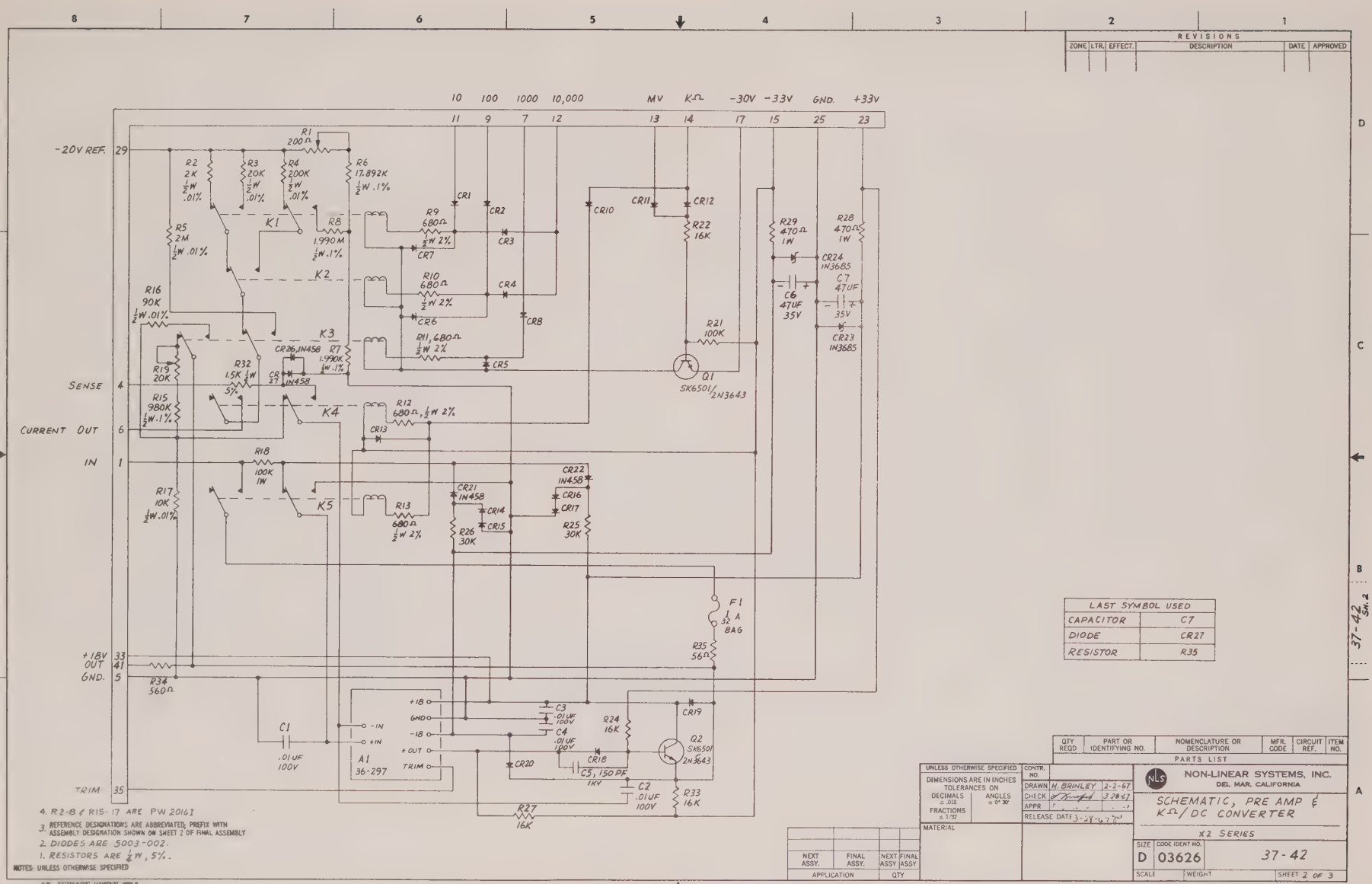
SCHEMATIC-
ATTENUATOR ASSY
SERIES X-2

SIZE	CODE IDENT NO.	
D	03626	37-39

SCALE | WEIGHT | SHEET 2 OF 3

37-2	37-2	1	1
NEXT ASSY.	FINAL ASSY.	NEXT ASSY	FINAL ASSY
APPLICATION		QTY	

37-39 rev. B



LAST SYMBOL USED	
CAPACITOR	C7
DIODE	CR27
RESISTOR	R35

NOTES: UNLESS OTHERWISE SPECIFIED

1. RESISTORS ARE ¼W, 5%.
2. DIODES ARE 5003-002.
3. REFERENCE DESIGNATIONS ARE ABBREVIATED; PREFIX WITH ASSEMBLY DESIGNATION SHOWN ON SHEET 2 OF FINAL ASSEMBLY
4. R2-8 & R15-17 ARE PW 2016I

REVISIONS					
ZONE	LTR.	EFFECT.	DESCRIPTION	DATE	APPROVED

QTY REQD	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MFR. CODE	CIRCUIT REF.	ITEM NO.

PARTS LIST

NEXT ASSY.	FINAL ASSY.	NEXT ASSY	FINAL ASSY
APPLICATION		QTY	

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON
DECIMALS ± .010
ANGLES ± 0° 30'
FRACTIONS ± 1/32
MATERIAL

CONTR. NO.
DRAWN H. BRINLEY 2-2-67
CHECK 3-28-67
APPR
RELEASE DATE 3-28-67

NON-LINEAR SYSTEMS, INC.
DEL MAR, CALIFORNIA

SCHEMATIC, PRE AMP & K-Ω/DC CONVERTER

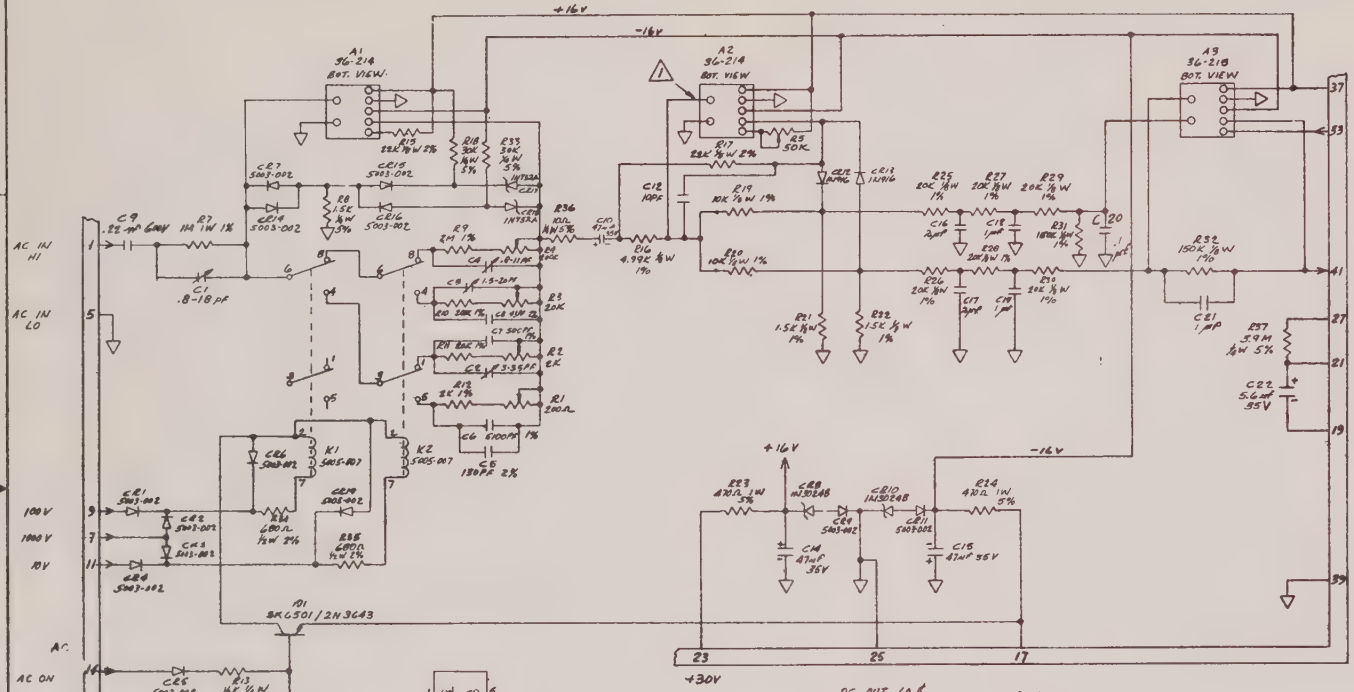
X2 SERIES

SIZE D | CODE IDENT NO. 03626 | 37-42

SCALE | WEIGHT | SHEET 2 OF 3

37-42 SH. 2

REVISIONS					
ZONE	LTR.	EFFECT.	DESCRIPTION	DATE	APPROVED
4C	A	A.L.N.	C16 & 17 (2MF/200V) WERE 1MF/250V	3-15-67	



CALIBRATION INSTRUCTIONS

PROC. NO.	RANGE	INPUT	ADJUST
1	1000V	0	REAR PANEL CONTROL (AC OFFSET)
2	1000 V	500V - 200 HZ	R1
3	1000 V	500V - 10K HZ	C1
4	100 V	100V - 200 HZ	R2
5	100 V	100V - 10K HZ	C2
6	10 V	10V - 200 HZ	R3
7	10 V	10V - 10K HZ	C3
8	1 V	1V - 200 HZ	R4
9	1 V	1V - 10K HZ	C4

⚠ THIS POINT SHOULD MEASURE 0v ± 1MV. IF NOT, ADJUST R5.

NOTES: UNLESS OTHERWISE SPECIFIED

QTY REQD	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MFR. CODE	CIRCUIT REF	ITEM NO.

PARTS LIST

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON
DECIMALS ± .010 ANGLES ± 0° 30'
FRACTIONS ± 1/32

CONTR. NO.		
DRAWN	MYCKLAND	2-1-67
CHECK		2-13-67
APPR		2-13-67
RELEASE DATE	2-13-67	

MATERIAL

NON-LINEAR SYSTEMS, INC.
DEL MAR, CALIFORNIA

SCHEMATIC
AC/DC CONVERTER
SERIES X2

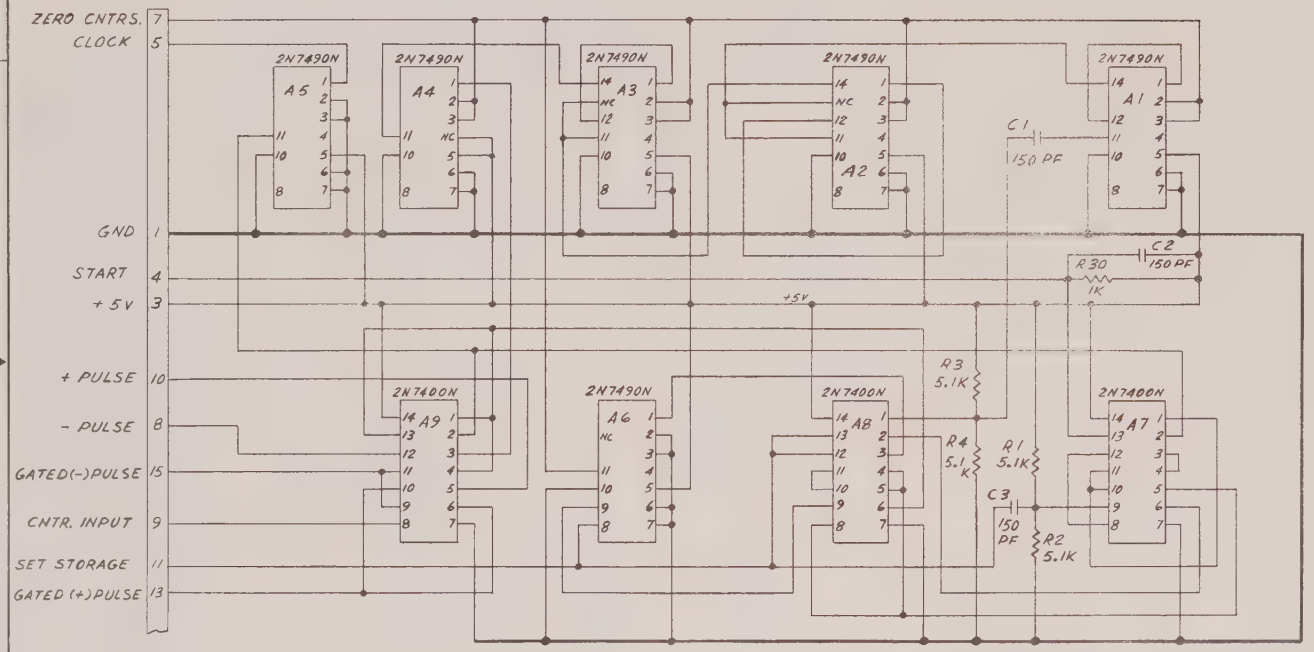
SIZE	CODE IDENT NO.	
D	03626	37-45

SCALE | WEIGHT | SHEET 2 OF 3

NEXT ASSY.	FINAL ASSY.	NEXT ASSY	FINAL ASSY
APPLICATION		QTY.	

37-45 SH 2

REVISIONS					
ZONE	LTR.	EFFECT.	DESCRIPTION	DATE	APPROVED
3B	A	ALL	CONNECTED A6-2,3,6&7 TO GND	2-17-67	[illegible]



QTY REQD	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MFR. CODE	CIRCUIT REF.	ITEM NO.

PARTS LIST

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON
DECIMALS ± .010
ANGLES ± 0° 30'
FRACTIONS ± 1/32

MATERIAL

CONTR. NO.		
DRAWN	WICKLAND	2-3-67
CHECK	[illegible]	2-13-67
APPR	[illegible]	2-13-67
RELEASE DATE		

NON-LINEAR SYSTEMS, INC.
DEL MAR, CALIFORNIA

START STOP ASS'Y.

SERIES X2

SIZE	CODE IDENT NO.	
C	03626	37-69

SCALE | WEIGHT | SHEET 2 OF 3

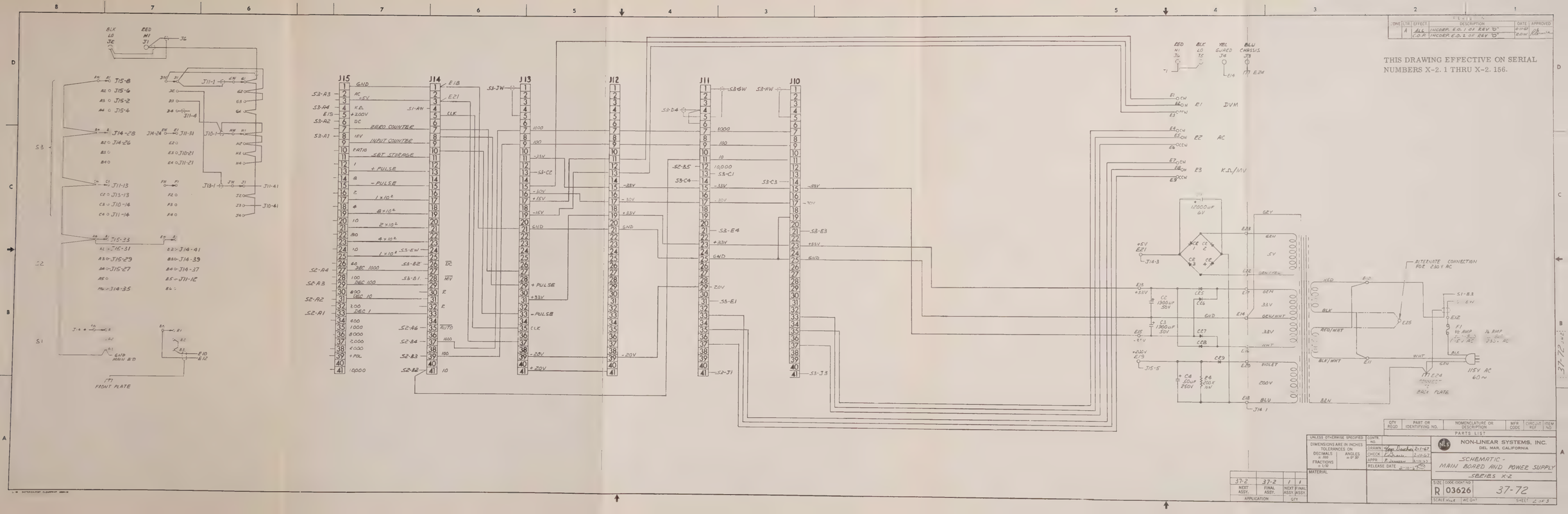
NEXT ASSY.	FINAL ASSY.	NEXT ASSY.	FINAL ASSY.
37-2	37-2	1	1
APPLICATION		QTY.	

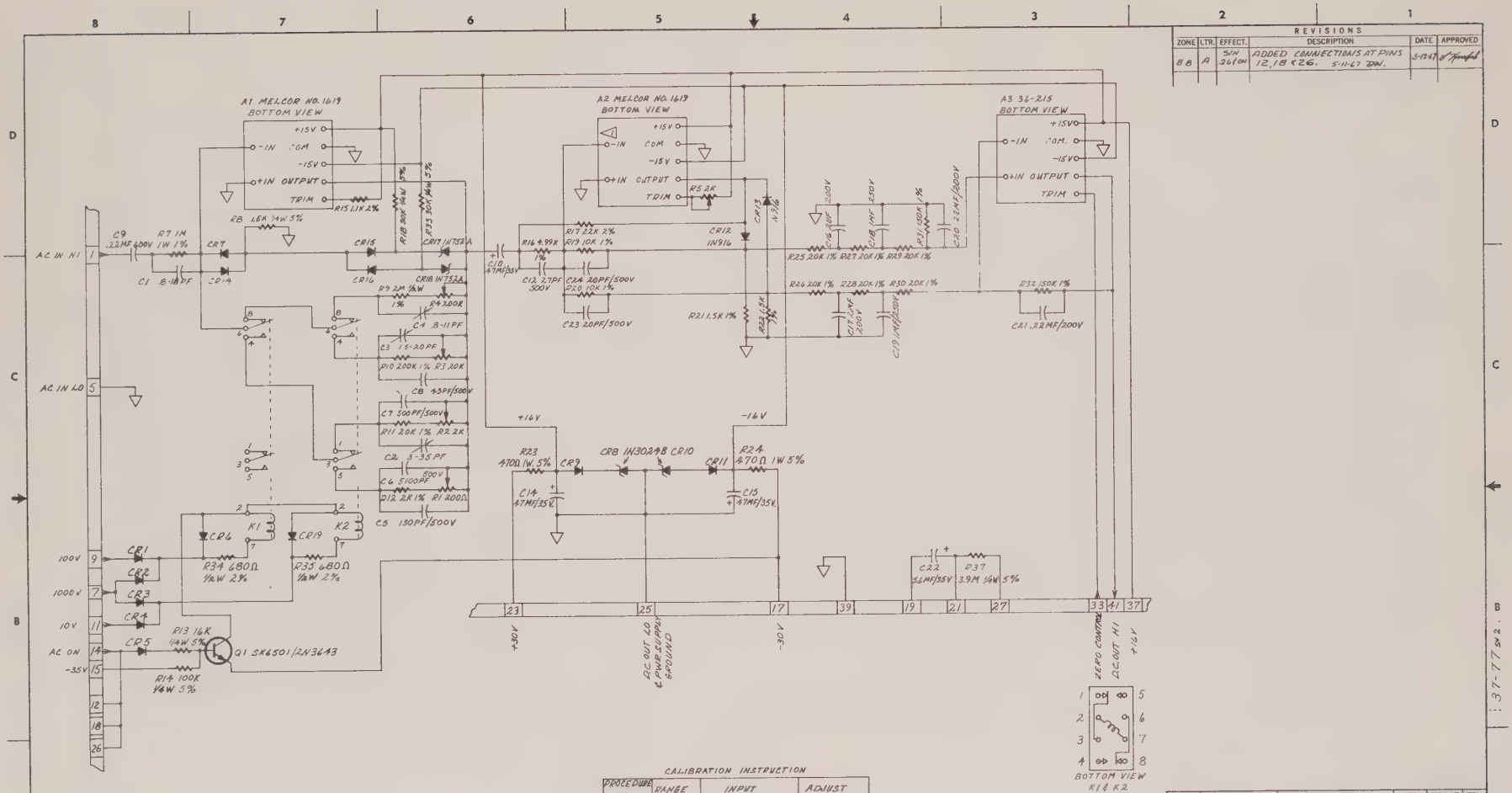
2. [illegible] ABBREVIATED. PREFIX WITH [illegible] SHOWN ON SHEET 2 OF FINAL ASSEMBLY

1. RESISTORS ARE 1/4 W, 5%, CARBON.

NOTES: UNLESS OTHERWISE SPECIFIED

37-69 SH2


BLK LO J2
RED HI J1
J2
J1
J11-1
J11-4
J14-28
J14-26
J14-24
J11-31
J10-1
J11-13
J13-13
J10-16
J11-14
J13-1
J11-41
J10-41
J15-33
J16-31
J16-29
J15-27
J14-41
J14-39
J14-37
J11-12
J14-35
J14-4
J14-2
GND MAIN B'D
E10
E12
FRONT PLATE
J15
J14
J13
J12
J11
J10
GND
AC
+ 20V
K.Ω.
DC
MV
E
TENTH
DVM
AC
K.Ω./MV
12000 uf 6V
CR 1
CR 2
CR 3
CR 4
C1 1300 uf 30V
C2 1300 uf 30V
C4 50 uf 250V
R6 2000 K 1W
+5V
+33V
-33V
-20V
+100V
-100V
+250V
GRY
GRN
BLK
RED/WHT
BLK/WHT
WHT
VIOLET
BRN
BLU
ALTERNATE CONNECTION FOR 230 V AC
F1 1/2 AMP 115 V AC
1/4 AMP 230 V AC
115V AC 60 ~
BACK PLATE
THIS DRAWING EFFECTIVE ON SERIAL NUMBERS X-2. 1 THRU X-2. 156.
REVISIONS
ZONE LTR EFFECT DESCRIPTION DATE APPROVED
A ALL INCORP. E.O. 1 OF REV D 6-21-67
C.O.A INCORP. E.O. 2 OF REV D 8-4-67
QTY REQD PART OR IDENTIFYING NO. NOMENCLATURE OR DESCRIPTION MFR CODE CIRCUIT REF ITEM NO.
PARTS LIST
UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES TOLERANCES ON DECIMALS ANGLES ± 0° 30' FRACTIONS ± 1/32
CONTR NO.
DRAWN Hope Bracken 2-1-67
CHECK [illegible] 2-10-67
APPR R Brunner 2-13-67
RELEASE DATE 2-16-67
MATERIAL
NLS NON-LINEAR SYSTEMS, INC. DEL MAR, CALIFORNIA
-SCHEMATIC- MAIN BOARD AND POWER SUPPLY SERIES X-2
SIZE R CODE IDENT NO 03626 37-72
SCALE NONE WEIGHT SHEET 2 OF 3
37-2 NEXT ASSY. 37-2 FINAL ASSY. 1 NEXT ASSY. 1 FINAL ASSY. APPLICATION QTY
37-72



REVISIONS					
ZONE	LTR.	EFFECT.	DESCRIPTION	DATE	APPROVED
B8	A	S/N 261 ON	ADDED CONNECTIONS AT PINS 12, 18 & 26. 5-11-67 JDW.	5-12-67	

CALIBRATION INSTRUCTION

PROCEDURE NO.	RANGE	INPUT	ADJUST (REAR PANEL CONTROL EXCEPT AS NOTED)
1	1000V	0	R1
2	1000V	500V - 200HZ	R1
3	1000V	500V - 80KHZ	C1
4	100V	100V - 200HZ	R2
5	100V	100V - 80KHZ	C2
6	10V	10V - 200HZ	R3
7	10V	10V - 80KHZ	C3
8	1V	1V - 200HZ	R4
9	1V	1V - 80KHZ	C4

6. ALL RELAYS ARE 5005-007
5. ALL RESISTORS ARE ⅛W
4. ALL DIODES ARE NLS 5003-002
3. AFTER CALIBRATION, SPOT CHECK AT VARIOUS FREQUENCIES THROUGHOUT BAND WIDTH OF CONVERTER.
2. REFERENCE DESIGNATIONS ARE ABBREVIATED; PREFIX WITH ASSEMBLY DESIGNATION SHOWN ON SHEET 2 OF FINAL ASSEMBLY
◁ THIS POINT SHOULD MEASURE 0V ± 1MV. ADJUST R5 FOR CORRECTION.
NOTES: UNLESS OTHERWISE SPECIFIED

NEXT ASSY.	FINAL ASSY.	NEXT ASSY.	FINAL ASSY.
APPLICATION		QTY	

QTY REQD	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MFR. CODE	CIRCUIT REF.	ITEM NO.

PARTS LIST

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON
DECIMALS ± .010
ANGLES ± 0° 30'
FRACTIONS ± 1/32
MATERIAL

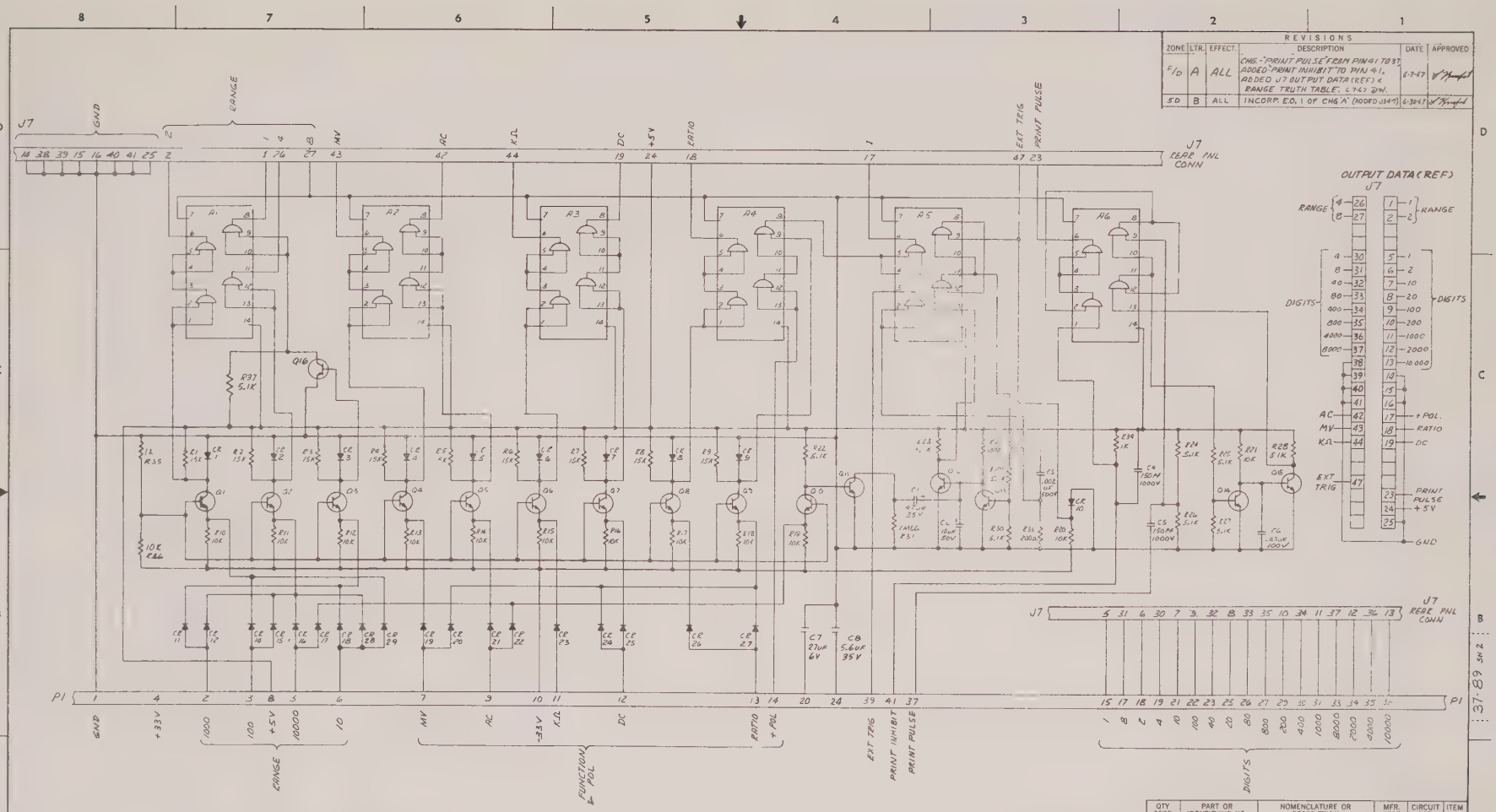
CONTR. NO.
DRAWN J.A. COMBS 3-16-67
CHECK [signature] 3-21-67
APPR. E. [illegible] 3-28-67
RELEASE DATE 3-28-67

NON-LINEAR SYSTEMS, INC.
DEL MAR, CALIFORNIA

SCHEMATIC
100KHZ AC/DC CONVERTER
SERIES X-2

SIZE	CODE IDENT NO	
D	03626	37-77
SCALE	WEIGHT	SHEET 2 OF 3

37-77 SH 2.



REVISIONS					
ZONE	LTR.	EFFECT.	DESCRIPTION	DATE	APPROVED
F/D	A	ALL	CHG. "PRINT PULSE" FROM PIN 41 TO 37. ADDED "PRINT INHIBIT" TO PIN 41. ADDED J7 OUTPUT DATA (REF) & RANGE TRUTH TABLE. C-7-67 DW.	6-7-67	
5D	B	ALL	INCORP. ED. 1 OF CHG "A" (ADDED J3&7)	6-30-67	

RANGE TRUTH TABLE +5V=TRUE

	8	4	2	1	DISCRETE NUMBER
0XXXX	1		1		4
0XXXX	10			1	3
0XX.XX	100			1	2
0XXX.X	1000			1	1
0XXXX	10000				C

5. ALL DIP ZN7400N
4. ALL RESISTORS ¼W, 5%
3. ALL TRANSISTORS 2N3711
2. ALL DIODES NLS 5003-002
1. REMOVE DIODES AND JUMPERS AS INDICATED, PREFIX WITH ASSEMBLY DESIGNATION SHOWN ON SHEET 2 OF FINAL ASSEMBLY

NOTES. UNLESS OTHERWISE SPECIFIED

QTY REQD	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MFR. CODE	CIRCUIT REF.	ITEM NO.

PARTS LIST

37-5 NEXT ASSY.	37-5 FINAL ASSY.	1 NEXT ASSY	1 FINA. ASSY
APPLICATION		QTY.	

UNLESS OTHERWISE SPECIFIED — DIMENSIONS ARE IN INCHES; TOLERANCES ON DECIMALS ± .010, ANGLES ± 0° 30', FRACTIONS ± 1/32

CONTR. NO.

DRAWN		3/31/67
CHECK		5-3-67
APPR		5-5-67
RELEASE DATE	5-5-67	

MATERIAL

NON-LINEAR SYSTEMS, INC.
DEL MAR, CALIFORNIA

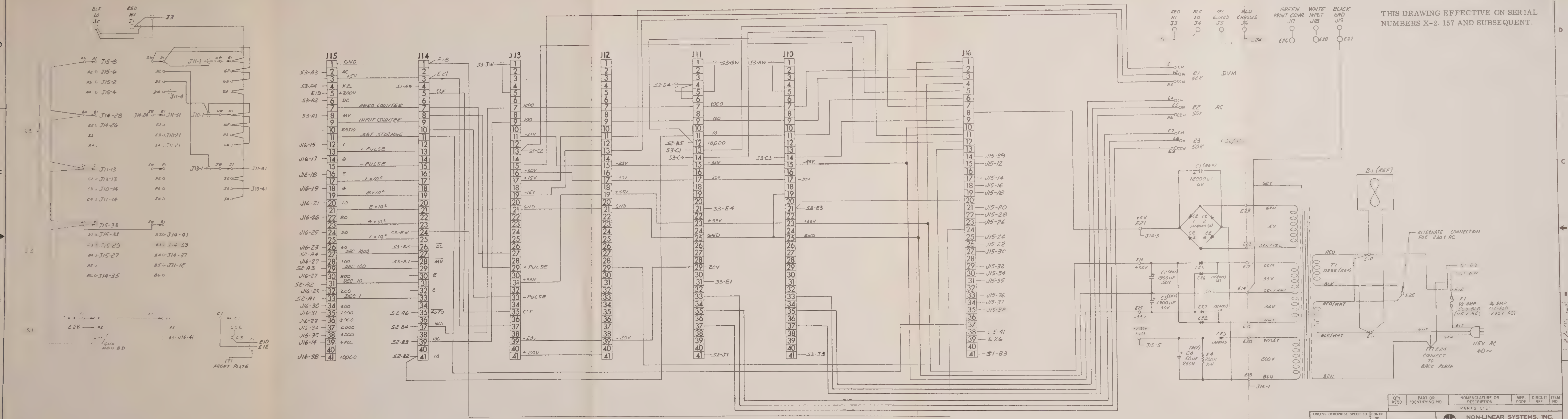
ASSY, PRINT BOARD SCHEMATIC

SERIES X 2

SIZE	CODE IDENT NO.	
D	03626	37-89

SCALE — WEIGHT — SHEET 2 of 3

37-89 SH 2


THIS DRAWING EFFECTIVE ON SERIAL NUMBERS X-2. 157 AND SUBSEQUENT.
J15
J14
J13
J12
J11
J10
J16
BLK LO J2
RED HI J1
J3
RED HI J3
BLK LO J4
YEL GUARD J5
BLU CHASSIS J6
GREEN PRINT COMP. J17
WHITE INPUT J18
BLACK GND J19
R1 50K DVM
R2 50K AC
R3 50K
C1 (REF) 12000uF 6V
CR 1 CR 2 1N4003 (4) CR 3 CR 4
+5V E21
C2 (REF) 1900uF 50V
C3 (REF) 1900uF 50V
CR5 CR6 1N4003 (2)
CR7 CR8 1N4003
CR9 1N4005
C4 (REF) 50uF 250V
R4 200K ½W
T1 D235 (REF)
B-1 (REF)
ALTERNATE CONNECTION FOR 230 V AC
F1 ½ AMP SLO-BLO (115 V AC)
¼ AMP SLO-BLO (230 V AC)
115V AC 60~
E24 CONNECT TO BACK PLATE
FRONT PLATE
GND MAIN BD
ZERO COUNTER
INPUT COUNTER
SET STORAGE
+ PULSE
- PULSE
DEC 1000
DEC 100
DEC 10
DEC 1
AUTO

REVISIONS					
ZONE	LTR.	EFFECT	DESCRIPTION	DATE	APPROVED

QTY REQD	PART OR IDENTIFYING NO	NOMENCLATURE OR DESCRIPTION	MFR. CODE	CIRCUIT REF	ITEM NO

PARTS LIST

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON
DECIMALS ± .010 ANGLES ± 0° 30'
FRACTIONS ± 1/32
MATERIAL

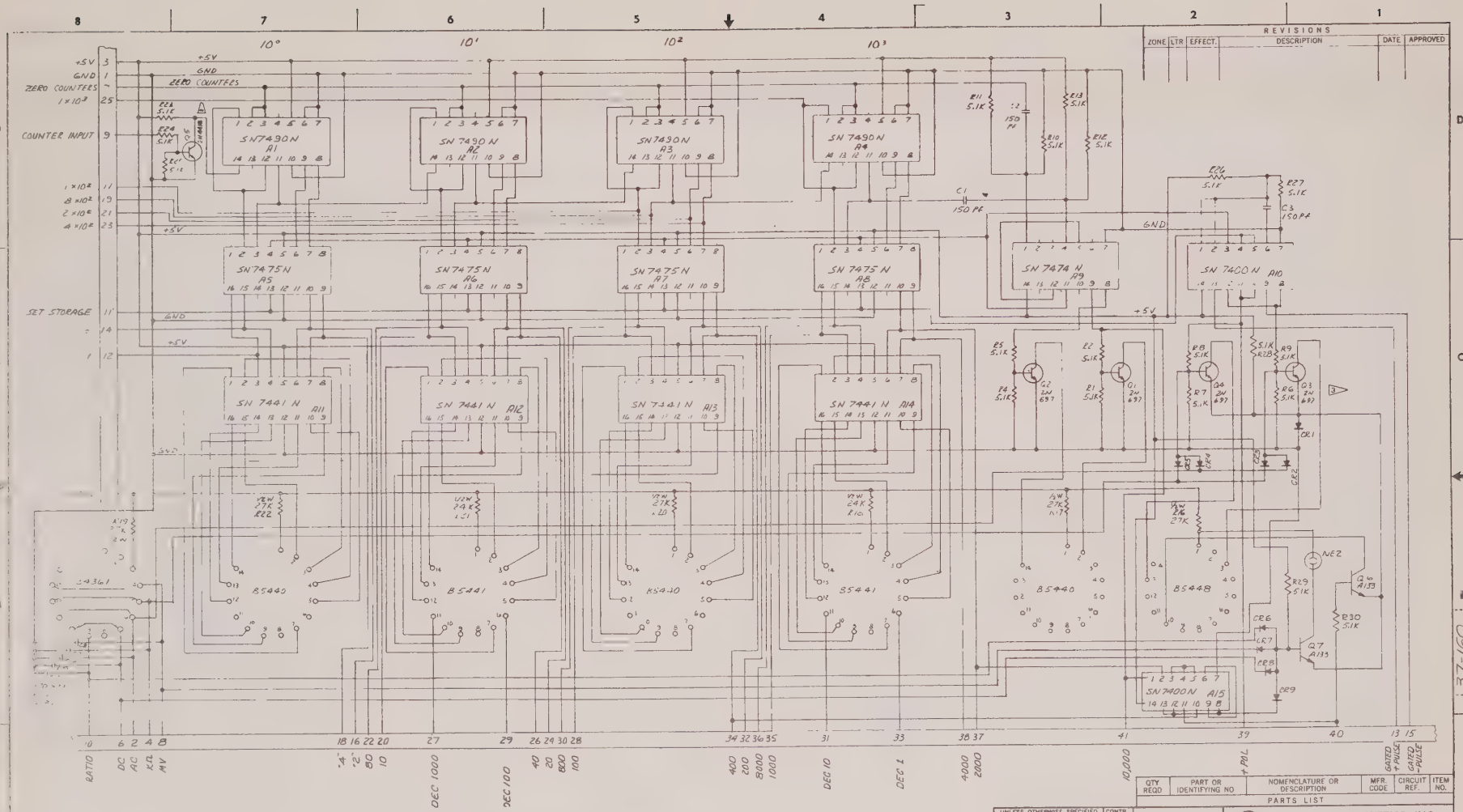
CONTR. NO.		
DRAWN	WEINBERG	4-19-67
CHECK	[signature]	6-5-67
APPR	[signature]	6-6-67
RELEASE DATE	6-6-67	

NON-LINEAR SYSTEMS, INC.
DEL MAR, CALIFORNIA

SCHEMATIC - MAIN BOARD AND POWER SUPPLY SERIES X-2 W/PRINT

SIZE	CODE IDENT NO.	
R	03626	37-105
SCALE None	WEIGHT	SHEET 2 OF 2

37-5	37-5	1	1
NEXT ASSY.	FINAL ASSY.	NEXT ASSY	FINAL ASSY.
APPLICATION		QTY.	



NOTE: This drawing effective S/N X-2. 302 & Subsequent.

Q1-4 ALTERNATE A-133, AMPEREX

Q5 ALTERNATE 2N2368 T1.

1. REFERENCE DESIGNATIONS ARE ABBREVIATED; PREFIX WITH ASSEMBLY DESIGNATION SHOWN ON SHEET 2 OF FINAL ASSEMBLY

NOTES: UNLESS OTHERWISE SPECIFIED

REVISIONS					
ZONE	LTR	EFFECT.	DESCRIPTION	DATE	APPROVED

QTY REQD	PART OR IDENTIFYING NO	NOMENCLATURE OR DESCRIPTION	MFR. CODE	CIRCUIT REF.	ITEM NO.

PARTS LIST

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON
DECIMALS ± .010 ANGLES ± 0° 30'
FRACTIONS ± 1/32

CONTR. NO.
DRAWN 6/23-67
CHECK D. Hanrahan 7-6-67
APPR. R. Brown 7-6-67
RELEASE DATE 7-6-67

MATERIAL

NON-LINEAR SYSTEMS, INC.
DEL MAR, CALIFORNIA

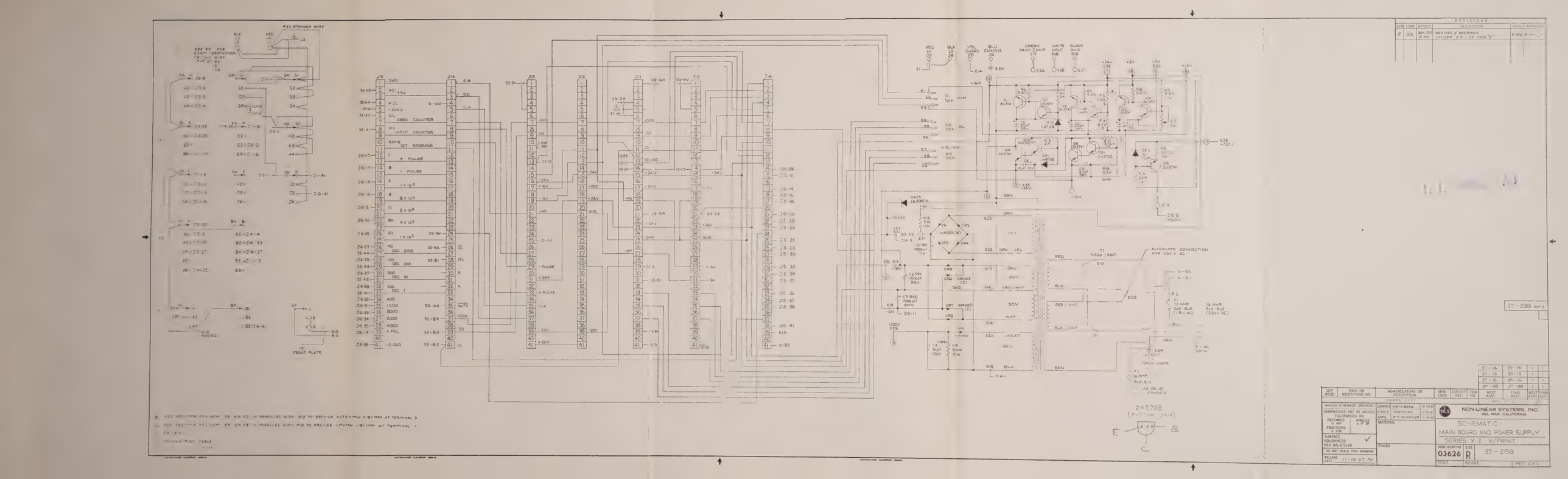
SCHEMATIC - DECADE
SERIES X-2

SIZE	CODE IDENT NO.	
D	03626	37-160

SCALE | WEIGHT | SHEET 2 OF 2

37-5	37-5	/	/
NEXT ASSY.	FINAL ASSY.	NEXT ASSY	FINAL ASSY
APPLICATION		QTY.	

37-160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NON-LINEAR SYSTEMS, INC.

DEL MAR, CALIFORNIA
714-755-1134 TWX 910-322-1025

15 March 1967

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OVERSEAS: NLS is represented in many countries. Please consult factory in Del Mar, California

non linear
systems, inc.

DEL MAR, CALIFORNIA